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A HISTORICAL GEOGRAPHY OF CAMBRIDGE, OHIO*

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Guernsey County, of which Cambridge is the county seat and only major city, is located within that section of the Appalachian Plateau Province which Fenneman designates as the Unglaciaded Allegheny Plateau.¹ Cambridge is 75 miles east of Columbus, 54 miles north of Marietta and 52 miles west of Wheeling, West Virginia.

The modern city of today with its brightly lighted business district, its many diversified industries, its excellent park and recreational facilities, bears little resemblance to the ferry town of 1803, when the majority of the people made their living farming the fertile land along the banks of Wills Creek.

With the defeat of the Indians in Ohio, the northwest was opened to settlement. Travelers from the east on reaching Wheeling, took flatboats down the Ohio River if they wished to go further west. The fact that the interior of Ohio could be reached only with great difficulty prompted Congress in 1796 to authorize Ebenezer Zane to blaze a trail from Wheeling to Limestone, Kentucky.² Zane was to open the trace and establish bridges or ferries over the larger streams but the smaller streams were to be forded.

Wills Creek was the first major crossing in the path of the trace. A ferry had to be established at this location. This ferry crossing was to be the nucleus around which the settlement of Cambridge was formed.

Employed by the Federal government to make a survey of the area, George Metcalf, a Virginian, was impressed by its latent possibilities. Writing his uncle, Jacob Gomber, he urged him to buy land in the area. In 1803, Gomber and his partner John Beatty purchased the land that now includes Cambridge, west to New Concord, for the sum of \$2,000.³

After purchasing the land, Gomber and Beatty, in 1806, laid out the town of Cambridge. They staked out houselots, 140 in all, and left the removal of the forests to the purchasers of the lots.⁴

In the years 1805-1806 Napoleon was making preparations for the invasion of England. For protection, the English stationed troops on the little island of Guernsey in the English Channel. This caused many inhabitants to leave the island and seek new homes. The first of these people reached Cambridge in August, 1806, on their way west. Impressed by the possibilities of the settle-

*This paper is a condensed form of an M.A. thesis prepared at Kent State University, Kent, Ohio.

¹Nevin M. Fenneman, *Physiography of Eastern United States*, (New York: McGraw-Hill Book Company, Inc., 1938), p. 290.

²*Ohio Archaeological and Historical Publication*, (Columbus, Ohio), Volume XIII, p. 312.

³Material obtained from Mr. Carl J. Rech, County Historian, Guernsey County, Ohio, September, 1949.

⁴William G. Wolfe, *Stories of Guernsey County, Ohio*, (Cambridge, Ohio: published by author, 1943), pp. 534-535.

ment they decided to stay and make their homes. With few exceptions the early settlers came to engage in agriculture. They were attracted by the favorable climate, the tillable land, and the fertile soil.⁵

In 1810, Cambridge was selected as the site for the county seat of the new governmental unit formed from parts of Muskingum and Belmont counties. It was perhaps the offer of Gomer and Beatty, founders of the town, to furnish without charge the lands and buildings to house the county offices, that led to Cambridge being chosen over Beymerstown (Old Washington).

Fifteen years later in 1825, Congress authorized the extension of the National Road westward.⁶ It was not until 1827, however, that the road was surveyed through Cambridge. In the early days of the road, wagoners hauling the agricultural products of the west to the markets at Wheeling were a familiar sight in town as well as the drovers and their livestock. Stagecoach companies ran a daily schedule from Columbus to Wheeling, passing through Cambridge. Each had a particular place in which to stop. Stagecoach companies had their taverns, drovers their drovestands, and the wagoners their wagonstands. The Hutchinson tavern located on the present site of the National Hotel had accommodations for everyone.

With the opening of the National Road a period of more rapid development set in. By 1837 Cambridge became an incorporated village with over 1000 inhabitants.⁷

The State Legislature, in 1847, authorized the construction of a railroad from the Ohio River west through Cambridge, Newark, and on to Columbus. The Central Ohio Railroad Company was to determine the route and construct the road. Seven years later passenger traffic was opened between Cambridge and Zanesville. Passenger traffic alone was not able to sustain the cost of operation and the railroad went into the hands of a receivership. In 1866 it became part of the Baltimore and Ohio Railroad.

With the railroad came the telegraph. Cambridge was now connected to the outside world by three means of communication: the National Road, the railroad, and the telegraph.

Approximately 20 years after the establishment of the Central Ohio Railroad, enthusiasm was aroused in Cambridge over the proposed construction of the Cleveland-Marietta railroad. The people of Guernsey county subscribed to \$153,000 worth of bonds to help finance the railroad through the county. In order to raise the required money, the village in 1873 purchased the farm area on the south side of Wills Creek and divided it into houselots for the railroad workers. The money derived from the sale of these lots was used to build the railroad. This new addition became known as the "South Side."⁸

The coming of the railroad inaugurated a period of considerable mining activity. Although coal was known to have existed in the area prior to this time, there were no facilities to transport it to the outside markets. With the railroads this situation was now changed and coal mining became one of the principal sources of wealth to the community.

With the development of the coal fields, and later the natural gas fields, plus the availability of clay, lumber, and water, and the excellent transportation facilities, incentive was given industries to locate in Cambridge.

⁵*Guernsey Milestones*, booklet of the Sesquicentennial Celebration, Cambridge, Ohio, August 31 to September 26, 1948, pp. 12-13.

⁶Arthur Butler Hulbert, *Historic Highways, the Cumberland Road*, (Cleveland, Ohio: Arthur H. Clark Company, 1904), Volume X, pp. 73-76.

⁷Col. P. B. Sarchet, *History of Guernsey County, Ohio*, (Indianapolis, Indiana: B. F. Bowen and Company, 1911), pp. 250-251.

⁸Information obtained from Mr. Carl J. Rech, County Historian, Guernsey County, Ohio, November, 1949.

In 1889, a concern from New Philadelphia agreed to establish a steel rolling mill in the city under the provisions that Cambridge was to furnish the site and provide \$30,000 towards the construction of the plant. In return the steel company was to use coal from the Cambridge field and employ local labor. The main products of the Cambridge Iron and Steel Company were corrugated sheets and sheets for roofing. Four years later the Morton Tin Plate Company was established in Cambridge. After a few years of operation these plants were purchased by the American Sheet Steel and Tin Plating Company. As a result of a later merger between this company and the Carnegie-Illinois Steel Company, the Cambridge plants became the property of the latter. Raw materials for processing were brought to Cambridge from Pittsburgh.⁹

The mills were located on opposite sides of town. The Cambridge Iron and Steel Company was in the northwest section (the present site of the Marion Power Sna Shovel Company) while the Tin-Plate company was in the southeast in the present vicinity of Universal Potteries. In both cases the plants were located in the valley of Wills Creek. As in the case of the railroad the village purchased land from the farmers to provide the sites for the plants and then divided the remainder into homesites to be sold to raise the necessary funds. As the land was not too desirable for residential purposes it was not developed to any great extent. Later small industries located in much of the area.

With all the plants in operation the Cambridge iron and steel industries were at their height during and immediately following World War I. Employment was given to over 1600 workers representing approximately 6,000 people. New businesses sprung up to provide goods and services to the rapidly growing population. It is obvious that much of Cambridge's material growth and prosperity resulted from the development of the iron and steel industry.

In addition to the iron and steel industry, furniture, pottery, and glass industries were established about the same time. The Cambridge Glass Company was established in 1901 by the National Glass Company of New York. Cambridge was chosen as the site of the plant because of its nearness to the natural gas fields of West Virginia and the sand beds in western Pennsylvania and eastern Ohio.¹⁰ As in former cases the city provided the site for the plant. Again land was bought and divided into homesites for the workers in the plant. This area became known as East Cambridge.

Although the pottery industry in Guernsey county dates back to the beginnings of the county, it was not until the first part of the 20th century that it became an important industry in Cambridge. The availability of clay deposits in the immediate vicinity plus the transportation facilities at hand with which to transport the manufactured articles to market, prompted Charles Casey to establish the Cambridge Art Pottery Company in East Cambridge. In 1925 control of the plant passed into the hands of the Globe China Company of Niles, Ohio. During the depression the plant curtailed operations. In 1936 the plant site was purchased by the Oxford Pottery Company of Byesville, Ohio, and the name was changed to the Universal Potteries, Inc. Among the many articles manufactured are semi-porcelain dinnerware, tiling and brick. It is now one of the largest potteries in the United States.

The present population of Cambridge is over 21,000, an increase of approximately 6,000 over 1940.¹¹ The native born white population is by far the dominant group. There is a small Negro population and a yet smaller group of foreign

⁹Wolfe, *op. cit.*, pp. 634-635.

¹⁰Material obtained from personal interviews with members of the staff of the Cambridge Glass Company, Cambridge, Ohio, as well as from various papers and pamphlets furnished by the glass company, September, 1949.

¹¹Statistics obtained from personal interview with the Secretary, Chamber of Commerce, Cambridge, Ohio, September, 1949.

born inhabitants. From a general point of view the standard of living is relatively high. There are few very wealthy families and on the other hand few poor families in the city. Pride in the community is shown by the well-kept homes, the well-maintained roads and the excellent park and recreational facilities that are municipally owned and operated.

The city proper is spread over an area of approximately four square miles. The streets follow a rectangular pattern developed around the original platted village of 1806. The boundary of the original village approximates that of the present main business center.

Land use in Cambridge is divided into three major and four minor groups. The major group includes residential, commercial, and manufactural establishments. The minor group includes educational, religious, governmental, and recreational.

The residential sections of the city are largely located to the north and south of the central business core. The residences do not vary to any great extent in regard to size and maintenance. The exceptions to this generalization are the few superior dwellings located near the city park and a few below-average dwellings in the sections surrounding the main industrial areas. In either case the area involved is not too large in extent.

The business district is centrally located in the city, occupying six city blocks on each side of Wheeling Avenue. It extends from the foot of Wheeling Avenue hill on the west to the intersection with U. S. Route 21 on the east. The business district consists of retail stores and service establishments intermixed with several small wholesale establishments. The buildings are two to three stories high and for the most part constructed of brick. The first floor is used for retail and service stores while the second and third floors are used for offices, residences, and warehousing. Two of the larger categories of establishments are the wearing apparel stores and restaurants. The very large number of restaurants, gas stations, tourist homes, and hotels suggests the very great importance of the transient trade to the city. Other than in the business district there are very few commercial establishments. The almost complete absence of neighborhood grocery and drug stores is evident. The majority of the people, as in the past, come to the main center to do their shopping. Outlying business sections of a small scale may be found to the west and southeast of the main center.

During the depression of 1933-1939, the cessation of operations of the iron and steel industries and the closing of the mines brought unemployment and hardship to the working people and their families. Cambridge was often times referred to as a ghost city.¹² This situation was remedied by the development of the plastic industries. There are now ten separate plastic companies in Cambridge. The Cambridge Glass Company, Universal Potteries, Suitt Brothers Furniture, and the plastics companies now utilize the excess labor supply created by the loss of iron and steel and mining industries. There are now 28 separate manufacturing establishments employing over 4,000 people.¹³

In addition to employment supplied by the various commercial and industrial establishments in the city, over 700 are employed at the Cambridge State Hospital for the mentally ill, 3½ miles north of the city on U. S. Route 21. This hospital was built for the U. S. Army during the early years of World War II.

CONCLUSION

By the study of land-man associations in Cambridge during various periods of occupancy, it has been possible to gain an insight into some of the significant

¹²*Guernsey Milestones, op. cit.*, p. 44.

¹³Cambridge Chamber of Commerce, publication of June, 1949.

factors in the development of the city. The study has shown why the site was selected and how the community has grown.

The future is partially predictable. Since Cambridge is without competition, in its county, it will probably continue to be the seat of governmental and social activities. Situated as it is with an excellent communication system centering on the town, it will continue to be the commercial center of the area. The future prosperity, however, will depend chiefly on the manufactural evolution within the city. The importance it once held as a coal mining and steel manufacturing center no longer exists. Today the plastics, glassworks, pottery, furniture, and other smaller industries have established Cambridge as a light manufacturing center.

Visit the JUNIOR ACADEMY SCIENCE EXHIBITS
at the Ohio Academy of Science Annual Meeting,
Miami University, Oxford, Ohio, April 6, 1951.

A STUDY OF SUGAR FOR EMERGENCY FEEDING

Sugar as the base for emergency rations for civilian populations will be studied by the Department of Nutrition, Harvard School of Public Health, under a grant by the Sugar Research Foundation. Six new projects dealing with aspects of sugar in human nutrition will also be inaugurated. A total of \$146,831 has been appropriated for grant-in-aid supported research for the coming year.

Dr. Frederick J. Stare, director of the Harvard project, will attempt to determine whether the cheapness, stability, and high caloric value of sugar recommends it for use in emergency periods of food shortage when calorie deficiency is the most important factor. Efforts will be directed to incorporating protein from skim milk, yeast, or other substances with the addition of synthetic vitamins to a sugar base. Methods of making palatable, compact and economical rations in this way will be worked out in research kitchens to provide a food product that will be valuable in the event of a national disaster.

Other grants were to: Dr. John Haldi, Emory University, Georgia, for a study of the effect of different kinds of foods on the rate of tooth decay in laboratory animals; Dr. Jerome M. Waldrom, Jefferson Medical College of Philadelphia, for investigating the effect of sugar in preventing increased thickening of blood which follows ingestion of fat, a possible factor in thrombosis; Dr. Donald M. Watkin, Boston City Hospital, to study the role of carbohydrates, particularly sugar, in reducing diets for the treatment of overweight; Dr. Otto Meyerhof, University of Pennsylvania School of Medicine, for basic studies of sugar metabolism; California Foods Research Institute, San Francisco, for studying the effect of added sugar on the palatability of quick-frozen green peas; Belmont Chemical Sales Development Co., Chicago, to complete classification of sugar derivatives according to cost of commercial production.

SOME CYTOECOLOGICAL ASPECTS IN THE EVOLUTION OF CERTAIN SPECIES OF THE PLANT GENUS *SILENE*¹

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In this paper ecological, cytological, and genetical viewpoints are considered in analysis of the nature of the relationships between various species of the genus *Silene* and between closely related genera. In addition, the processes which are of evolutionary significance within the genus and between closely related genera are analyzed.

The genus *Silene* was first defined by Linnaeus in *Systema Naturae*, ed. 1, 1735, and *Genera Plantarum*, ed. 1, 1737. The genus was established in *Species Plantarum*, ed. 1, 1753, and as so delimited contained 26 species. The genus was revised superficially in 1824 by Oth in de Candolle's *Prodrromus* and extensively in 1868 by Rohrbach. The latest revision of the entire genus was made by Williams (1896) who built upon the work of Rohrbach and who enumerated 390 species in his monograph. However, according to the records of Hitchcock and Maguire (1947) 200 more species have since been proposed. There is need of a further revision.

In North America the genus *Silene* was first monographed by Torrey and Gray (1838) who recognized 23 species; Robinson enumerated 45 species in his revision (1897); and Hitchcock and Maguire (1947), in the latest revision of the North American representatives of *Silene*, listed 54 species.

The genus *Silene* is widely distributed throughout the northern hemisphere and includes approximately 600 species, most of which occur in Europe, Asia, and northern Africa. Because the genus is exceedingly large and morphologically ill-defined, it is only with difficulty that it is separated from closely-related genera on morphological characters alone. In 1812 Rohling separated *Silene* from *Melandryum* (*Melandrium* of other authors) on the basis of the presence or absence of a partial septation in the capsule. Rohrbach (1868) accepted this generic character as did Williams (1896). If this character is used to limit the genus, many of the North American species and most of the species from the province of Yun-man would be transferred to the genus *Melandryum*. However, none of the American workers has recognized this criterion. Robinson points out that partial septation of the capsule is not a trustworthy character in American species because *Silene virginica* which is generally referred to *Melandryum* by continental authors often shows the partial septation of a "true" *Silene*; and *S. multinervia*, a "good" *Silene* by habits and affinity to others of the group, often has no trace of septation. This variable and intermediary condition found in most American species has led Hitchcock and Maguire to follow Robinson (1897) in not accepting American forms with unilocular capsules as representatives of a distinct genus, *Melandryum*.

Of the species studied in the present investigation, *Silene virginica* L., *S. rotundifolia* Nutt., *S. laciniata* Cav., and *S. regia* Sims are referred to the genus *Melandryum* by European workers; and *S. latifolia* Mill., *S. maritima* With., *S. stellata* L., and *S. fortunei* Vis. are classified as *Silene* by both groups of workers.

From this brief outline of the history of the taxonomic work on the genus *Silene*, it is evident that this genus must necessarily be approached from viewpoints other than morphological ones alone.

¹Department publication 523. Personal acknowledgments are made to Dr. John N. Wolfe and Dr. Elton F. Paddock of The Ohio State University.

METHODS AND PROCEDURES

Mature plants of *Silene virginica* and seed from *S. rotundifolia* were collected in Hocking County, Ohio. Seed from *S. fortunei*, *S. laciniata*, *S. regia*, *S. stellata*, *S. maritima*, and *S. latifolia* were obtained from a commercial seed house. The seed was planted in December, 1948, and, following germination and growth, the plants began to flower in the spring of 1949. Various cross pollinations were made at this time to see which species were interfertile and to obtain hybrid material in which the interactions of the genomes of these species could be studied in various combinations. Cross pollinations of all possible combinations were not realized for the flowering periods of some pairs of species did not overlap. Not all of the cross pollinated species were cross fertile. Seed obtained from the successful crosses was planted in the fall of 1949 and the hybrid seedlings grew vigorously in each instance.

The fertility of these hybrids was tested in the spring of 1950 by making hand pollinations. The meiotic behavior of the chromosomes in both the parents and the F_1 individuals was observed on slides, each made by smearing the anthers of one bud in acetocarmine. Before smearing, the buds were fixed in a 3:1 absolute alcohol:acetic acid solution.

The photomicrographs were taken from permanent slides. The magnification of each of these photomicrographs is approximately 1400 except figure 2C, which is magnified approximately 330 times.

The geographic distributions of *S. maritima*, *S. latifolia*, *S. regia*, *S. laciniata*, and *S. fortunei* were plotted, based on data obtained from herbarium specimens obtained from New York Botanical Gardens, University of California at Los Angeles, West Virginia University, Brooklyn Botanic Gardens, the United States National Herbarium, and The Ohio State University.

THE PARENTAL SPECIES

The morphological characteristics which are used to separate the American species of *Silene* from the American species of *Melandryum* are variable and thus do not constitute a good basis for a natural system of classification. The base chromosome number of each of these genera is 12. Blackburn (1928) has reported the chromosome number for 45 species of *Silene* and 13 species of *Melandryum*. Of *Silene*, 41 species native to Europe, Asia, and North Africa, 1 species circumpolar in distribution, and 1 species native to North America have an n chromosome number of 12. The two other species of *Silene* are polyploid. Ten of the species of *Melandryum* native to the Old World have an n chromosome number of 12, while the 3 North American species have an n number of 24. Blackburn noted that the New World *Melandryum* species differed from the Old World species of the genus in that they were tetraploid. She stated that this difference was not paralleled in the genus *Silene* since *S. antirrhina*, the one New World species examined, has an n number of 12 as do most of the other widely-distributed species of this genus. In the present study the n chromosome number of a "true *Silene*," *S. stellata* L., var. *scabrella*, which is native to North America, was found to be 24 (fig. 2E). Thus, polyploids occur in the New World species of *Silene* as well as among the species of *Melandryum*, and American species, therefore, cannot be separated into these two genera on the basis of their chromosome numbers.

Blackburn reported that meiosis was regular in *S. latifolia* and *S. maritima* and that the n chromosome number of each of these Old World species is 12. *S. latifolia*, which has been introduced into North America, is a weed-like species that has spread throughout open fields, meadows, roadsides and forest borders from Maine, south to Virginia, southwest to Arkansas, and northwest to Washington and Oregon. *S. maritima* is confined to habitats along the sea coasts of England, Scotland, Ireland, Iceland, Norway, France, and Portugal. These

two species are reciprocally cross fertile (table 1), a finding in agreement with the work of Marsden-Jones and Turrill (1928). The resulting F_1 hybrids are fertile and seeds develop within the ovaries following open pollinations. No viable embryos develop following cross pollination between the diploid *S. maritima* or *S. latifolia* and the North American polyploid species *S. regia*, *S. rotundifolia*, or *S. laciniata*. *S. regia*, *S. rotundifolia*, *S. laciniata*, and *S. virginica* are cross fertile in all possible combinations (table 1). These polyploid North American species of *Silene* (considered species of *Melandryum* by European workers) are thus probably more closely related to one another than to the diploids *S. latifolia* and *S. maritima*. *Silene* is an exceedingly large and diversified genus, so it would not necessarily be expected that all members of this genus would be cross fertile. Williams (1896) noted that the members of the genus *Silene* "hybridize with difficulty," so it may well be that these two groups of species are merely rather distantly related species in *Silene*. Another factor to be considered is that cross fertilization might occur under other environmental conditions. The capsule septation basis for the separation of the North American species of *Silene* into two genera is of dubious value, both groups have the same basic chromosome number, and polyploids occur within both groups. The difference in the cross-

TABLE 1

Results of Cross Pollinations of *Silene* Species Made During the Summers of 1949 and 1950.*

♂	<i>fortunei</i>	<i>laciniata</i>	<i>latifolia</i>	<i>maritima</i>	<i>regia</i>	<i>rotundifolia</i>	<i>virginica</i>
♀							
<i>fortunei</i>	S	NCF	X	NCF	NCF	NCF	X
<i>laciniata</i>	X	S	X	X	S	S	S
<i>latifolia</i>	NCF	NCF	S	S	NCF	NCF	X
<i>maritima</i>	NCF	NCF	S	S	X	NCF	X
<i>regia</i>	X	X	X	X	S	S	S
<i>rotundifolia</i>	X	X	X	X	X	S	S
<i>virginica</i>	X	X	X	X	X	X	S

*X=no crosses attempted; S=seed obtained; NCF=no cross fertilization.

ability reported above, may be the result of the differences in the chromosome number of the species crossed. Because at the present time there is no evidence which makes it necessary to place these two groups in separate genera, it is suggested that they be considered members of one genus as the American workers have done in the past.

Silene fortunei Vis. is native to southeastern China and the Islands of Chusan and Formosa. Its habitats include grassy slopes, canyon sides, and river banks. This species, which has been classified as *Silene* by all who have worked with the genus, has an n chromosome number of 15 (fig. 1 C, D). *S. sinowatsoni*, another species native to China, has an n chromosome number of 12 (Blackburn, 1928). The base chromosome number for *Silene* is 12. Within this genus, none of the species which have been examined cytologically has an n chromosome number other than 12 or a whole multiple of 12. Not only is the chromosome number constant within this genus, but meiosis is an exceedingly regular process. It is thus difficult to even speculate upon a method by which an n number of 15 might originate within the genus unless it would be by intergeneric hybridization. However, there is no foundation for such a speculation. It is suggested that this species be transferred to another genus. Members of the genus *Vaccaria* and of the genus *Dianthus*, both of which are closely related to *Silene*, have a base number of 15. Because of the limited number of plants of this species examined, a sug-

gestion is not offered at this time as to whether it should be transferred to either of these two genera or to some other closely related genus or to a separate, new genus.

Of the four red-flowered species of *Silene* investigated, *S. regia* (fig. 1 E), *S. virginica* (Blackburn, 1928; Heaslip, 1950), and *S. rotundifolia* (Heaslip, 1950) are tetraploids and *S. laciniata* (fig. 2 D) is an octoploid. Meiosis is regular in each

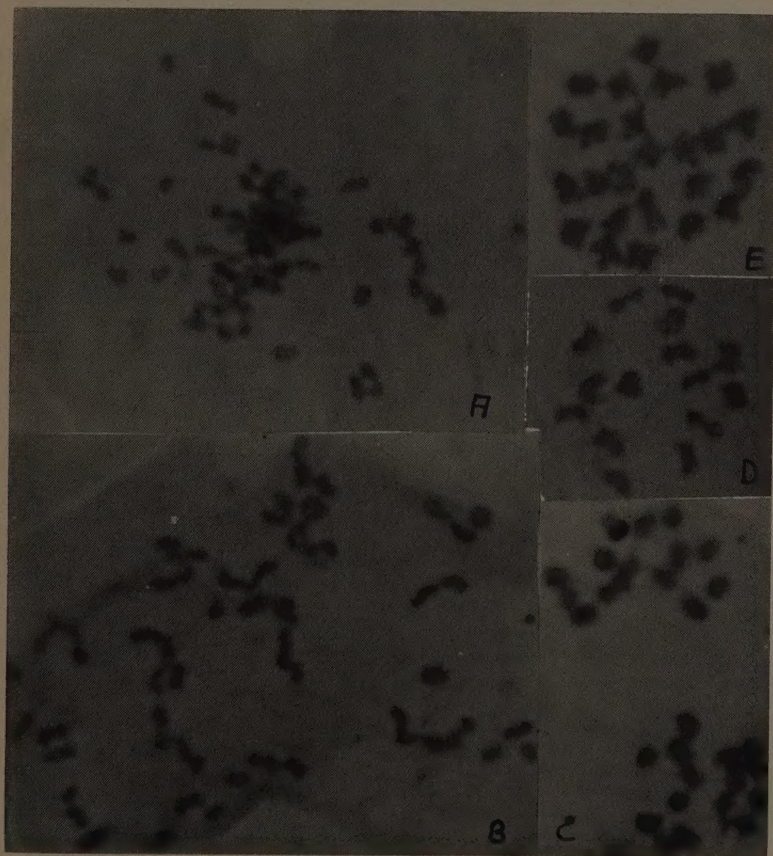


FIG. 1. (A) Hybrid of cross between *S. laciniata* and *S. rotundifolia*: metaphase I; pairing is irregular, note multivalents on the right side of the cell. (B) Hybrid of cross between *S. laciniata* and *S. rotundifolia*: polar view of early metaphase I; 1 quadrivalent, 5 trivalents, 17 bivalents, 19 univalents. (C) *S. fortunei*: anaphase I, 15 chromosomes at each pole of the spindle. (D) *S. fortunei*: metaphase I, 15 bivalents. (E) *S. regia*: metaphase II, polar view at one pole of the spindle. Photomicrographs by Dr. Joanne Parker.

of these species and no multivalents have been observed during meiosis. These species each appear to be completely self fertile. Because of this high fertility and the formation of bivalents only during the first meiotic division, it is probable that these species or their ancestors originated as amphiploids following inter-specific hybridization rather than as autopolyploids.

INTERSPECIFIC HYBRIDS

It has not been possible to synthesize any of these red-flowered species but studies were made to determine some of the interrelationships among them by analyzing meiosis in and by self- and back-crossing the following F_1 hybrids:

<i>S. rotundifolia</i> ♀	×	<i>S. virginica</i> ♂
<i>S. laciniata</i> ♀	×	<i>S. rotundifolia</i> ♂
<i>S. regia</i> ♀	×	<i>S. rotundifolia</i> ♂

Similar studies of the following F_1 hybrids were not possible for these plants were not in flower at the time of this report.

<i>S. laciniata</i> ♀	×	<i>S. regia</i> ♂
<i>S. laciniata</i> ♀	×	<i>S. virginica</i> ♂

Each of the F_1 hybrids investigated is vegetatively vigorous and has an extended flowering period. Although many of the flowers which occur on these hybrids are perfect, a large number of pistillate flowers occur on some plants. Stamens are formed in the pistillate flowers but they abort before the flowers open. The formation of either pistillate or perfect flowers is not correlated with length of day as it is in ragweed (Allard, 1945) for both types of flowers occur at the same time on the same plant. The occurrence of pistillate flowers is probably not entirely genetically controlled either, since both types of flowers sometimes occur within the same inflorescence. The amount of pollen formed in each anther of a hybrid flower is much less than in an anther of either parent, but the size and shape of all the pollen grains are similar. In the plants of each species used as parents the petals open, 5 stamens elongate, the anthers dehisce, and the other 5 stamens and the styles elongate or the other 5 stamens elongate followed by the elongation of the styles, and finally there is an expansion of the 3 stigmas. Pollination often occurs as the pistils grow to their final height. Because the stamens of the hybrid flowers sometimes never elongate, or the anthers do not dehisce until the pistils have grown above them, or the filaments collapse before the anthers dehisce, pollination often fails to occur. If pollination does occur by either natural or artificial means, the ovary begins to enlarge and then dehisces when mature; but only shrunken, shriveled ovules occur within the capsule. Seed formed in the ovaries of self pollinated flowers on plants of each of the parent species at this time. Because all these groups of plants were subjected to the same environmental conditions, the hybrid sterility was not considered to be the result of an unfavorable environment.

Heaslip (1950) reported that the F_1 hybrid of the cross *S. rotundifolia* ♀ and *S. virginica* ♂ was both self and cross sterile. This sterility was attributed in part or wholly to meiotic irregularities such as failure of synapsis, formation of multivalents, lagging, and polyspory.

The F_1 hybrids of the cross *S. laciniata* ($n=48$) ♀ and *S. rotundifolia* ($n=24$) ♂ are basically hexaploids ($n=36$). This hybrid has visible characteristics of both parents. The stems are usually simple as in *S. laciniata*, freely branching, weak, decumbent as in *S. rotundifolia*, viscid-puberulent, as in both; the leaves are intermediate in size and shape between those of both parents, the cauline leaves being sessile, broadly lanceolate (twice as long as broad); basal leaves are more rounded, winged petiole; inflorescence is open, flowers are more numerous than in either parent, more pubescent and viscid than other plant parts as in *S. laciniata*; corolla showy, color intermediate, the petals deeply bi-lobed, usually with an additional pair of smaller lateral lobes as in both parents.

Hundreds of the flowers on these hybrids were open pollinated and no seed formed, but this may have been the result of a failure of pollination. However, no seed formed following self- or back-crosses in which hand pollination was

practiced. *S. laciniata* and *S. rotundifolia* are thus closely enough related to be cross fertile; however, the vegetatively vigorous F_1 hybrid is sterile.

Many meiotic irregularities are observable during microsporogenesis in the anthers of this hybrid. Chromosome pairing is highly irregular and variable from cell to cell. Univalents, bivalents, and trivalents occur commonly (fig. 1 B);

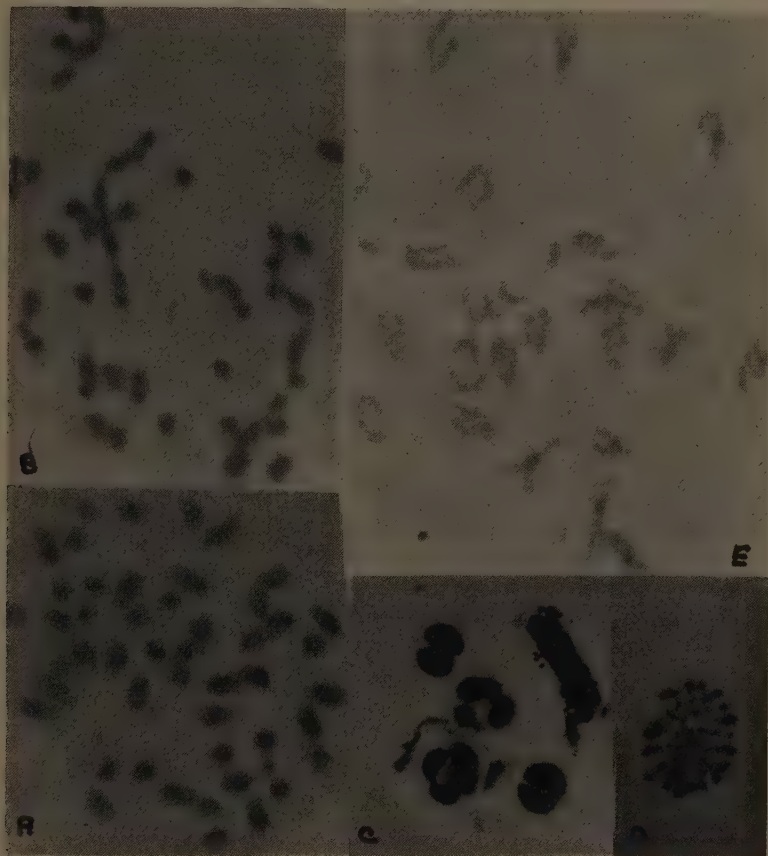


FIG. 2. (A) Hybrid of cross between *S. regia* and *S. rotundifolia*: metaphase I, most of the 48 chromosomes are present as univalents, no multivalents present. (B) Hybrid of cross between *S. regia* and *S. rotundifolia*: metaphase I, many multivalents present. (C) Hybrid of cross between *S. regia* and *S. rotundifolia*: polyspory. (D) *S. laciniata*: metaphase II, polar view at one pole of the spindle. (E) *S. stellata*: diakinesis, 24 bivalents. Photomicrographs A, B, C, D by Dr. Joanne Parker, E by Tillman Johnson.

quadrivalents and multivalents involving as many as 6 chromosomes occur occasionally (fig. 1 A). Numerical disjunction must not be regular for at anaphase I the number of chromosomes is not always equal in each of the polar groups. Such irregularities upset the genetic balance and may result in functional failure of the resulting gametes.

The chromosomes of each of the parents are so similar in size and shape that those of *S. laciniata* can not be distinguished from those of *S. rotundifolia* when they occur in the same cell of the hybrid. Therefore it is not possible to tell by observation whether allosyndesis or autosyndesis is occurring. Because trivalents, quadrivalents, and hexavalents do occur it is inferred that some of the chromosomes which synapse must come from the same parent. Autosyndesis does not occur in either parent but when chromosome sets of a polyploid are left without a partner, they frequently synapse autosyndetically (Darlington, 1937). The chromosomes from both parents are also involved in some of this pairing for multivalents involving more than 4 chromosomes occur. If synapsis can be used as an index for chromosome homology, then it can be inferred that *S. laciniata* and *S. rotundifolia*, which have chromosomes that synapse, are genetically closely related.

F₁ hybrids of the cross *S. regia* ♀ ($n=24$) and *S. rotundifolia* ♂ ($n=24$) are basically tetraploid. In these hybrids the stems are several, freely branching, weak, decumbent or ascending as in *S. rotundifolia*; leaves are intermediate between those of both parents, the cauline leaves are sessile, broadly lanceolate (once and a half as long as broad), lower leaves winged-petiolate; pedicels are densely viscid puberulent; calyx is densely viscid puberulent, tubular, becoming expanded by the maturing fruit as in *S. regia*; inflorescence is more pubescent and viscid than other parts of the plant; petals are shallowly bi-lobed and intermediate between those of both parents in color and shape.

These hybrids were in flower for approximately one month, but no seeds developed in any of the ovaries following hand pollinations. However, the ovaries increase greatly in size following pollination. Only back-crosses were made up to this report for the stamens in all the flowers which had opened had aborted. Both stamens and pistils abort in all of the flowers on some of these hybrids before anthesis.

Microsporogenesis in the anthers of this hybrid is irregular but pollen grains do form before the stamens abort. Synapsis is highly irregular and variable from cell to cell. At metaphase I in some cells, the greatest majority of the chromosomes are present as univalents (fig. 2 A), in others various multivalents occur (fig. 2 B). Instead of 4 microspores forming from each microspore mother cell, often more than 4 microspores, or 4 microspores and a variable number of micronuclei, form (fig. 2 C). Here again it is impossible to differentiate between autosyndesis and allosyndesis by observation alone but it can be inferred that the chromosomes of both parents are involved when multivalents involving more than 2 chromosomes occur. Since this synapsis does occur the best inference is that *S. rotundifolia* is genetically closely related to *S. regia*.

DISCUSSION

According to biosystematic criteria each of these 4 red-flowered species would be classified as an ecospecies for each has a separate genetic system that is balanced externally and internally, the genes of one of these species are not freely interchanged with those of another, and constitutional genetic barriers exist between them. All of these ecospecies would belong to the same cenospecies as there is a possibility of a limited interchange of genes from one species to another.

The relationship among these does not seem to be in a straight line nor does it appear to have a simple pattern. From the data at hand, it seems to be a complicated, reticulate pattern. *S. rotundifolia* has some chromosomes in common with *S. regia*, *S. virginica*, and *S. laciniata*; however the relationship is in no case great enough for the F₁ hybrid to be even partially fertile. No definite statements about the relationship of these four species can be made until the other hybrids are examined cytologically; however, some preliminary remarks can be made at the present time. The homology of some of the chromosomes of *S. rotundifolia* with the chromosomes of each of the other three species is an indication that these

species are interrelated through common ancestors. During speciation new chromosome combinations seem to have resulted from hybridization, apparently a series of hybridizations, for the synapic homologies appear to be for parts of genomes rather than whole genomes.

Each of these species is now isolated from each of the others so that at the present time no introgression is taking place. *S. rotundifolia* has a limited distribution through southern Ohio, Tennessee, Kentucky, West Virginia, Virginia, and northern Alabama and Georgia (Wolfe, Wareham, and Soodfeld, 1949). Members of this species occur only on limestone or sandstone rock ledges or cliff crevices. However, the ecological amplitude of *S. virginica* appears to be much wider than that of *S. rotundifolia*. *S. virginica* occurs in open forests, thickets, or on rocky slopes from New Jersey, western New York, and southwestern Ontario, southward into Missouri and Georgia (Hitchcock and Maguire, 1947; Fernald, 1950). The distribution of *S. regia* occurs within the range of *S. virginica* and to the west of the range of *S. rotundifolia*. *S. regia* grows in open woodlands but it is primarily a prairie species which occurs from eastern Missouri and Arkansas, into southern Illinois and Ohio, Tennessee, Kentucky, and northern Alabama and Georgia. Although the range of distribution of *S. virginica* overlaps that of *S. rotundifolia* and *S. regia*, these species are ecologically isolated. Turrill (1938), in a study of the distribution of *Silene* in the French Alps, found that *S. alpina* and *S. monobolus* were cross fertile but there was no amalgamating into a single polymorphic species because they are ecologically isolated. Not only are *S. rotundifolia*, *S. virginica*, and *S. regia* ecologically isolated but the sterility of the hybrids prevents these populations from becoming one species.

Hybrid sterility also is an effective barrier between *S. rotundifolia* and *S. laciniata*. *S. laciniata* subsp. *greggi* occurs on dry open slopes of southeastern Arizona through southern New Mexico into southwestern Texas, and south into Mexico. Thus *S. laciniata* is also geographically isolated from these other 3 species at the present time.

The difference between these species is probably not only the result of polyploidy and changes in the chromosome combinations, but gene mutations and reciprocal translocations have probably been important also. Because these morphologically distinct species have very similar karyotypes, it is inferred that gene mutations must have had a significant role in speciation. Evidence for the occurrence of reciprocal translocations was found in the F₁ hybrids of the cross between *S. rotundifolia* and *S. virginica* (Heasley, 1950).

Within the genus as a whole, polyploidy does not seem to have played as important a role as it has in the speciation of North American members. Of all the Old World species of *Silene* examined but 4 are polyploids: *S. shafera* and *S. tellesii* (Blackburn, 1928-1933), *S. pumila* and *S. tellesii* (Darlington and Animal, 1945).

SUMMARY

1. At the present time, there is no evidence which makes it necessary to separate the American species of *Silene* into two genera; thus, it is suggested that the North American species referred to as *Melandryum* by European workers be classified as *Silene* as American workers have done in the past.

2. The x chromosome number of *S. regia* = 24, *S. stellata* = 24, *S. laciniata* = 48, *S. fortunei* = 16.

3. It is suggested that it may be best to transfer *S. fortunei* to another genus.

4. Although *S. rotundifolia*, *S. regia*, *S. virginica* are basically tetraploids and *S. laciniata* is basically octoploid, meiosis is regular in each of these species, indicating amphiploid rather than autopolyploid origin.

5. These 4 species are thought to be interrelated in a complex reticulate pattern.

6. These 4 species are cross fertile in all possible combinations and all the resulting hybrids are vegetatively vigorous.

7. Meiosis is irregular in the F_1 hybrids of the cross between *S. laciniata* ♀ ($n=48$) and *S. rotundifolia* ♂ ($n=24$), and in those of the cross between *S. regia* ♀ ($n=24$) and *S. rotundifolia* ♂ ($n=24$).

8. The sterility of these hybrids is attributed to the formation of genetically unbalanced gametes.

9. Polyploidy, interspecific hybridization, gene mutation, and reciprocal translocation are processes which have undoubtedly occurred in the evolution of these species of *Silene*.

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Functional Anatomy of the Vertebrates. Daniel P. Quiring. 1950. McGraw-Hill Book Co., Inc., New York 18. xi+624 pp. \$5.50.

The author has developed a new approach to vertebrate anatomy and does not follow the conventional line of comparative anatomy texts closely, but rather develops the view that the behavior and performance of the animal is limited by various features of structure. Special emphasis is given to function and levels of organization with a consideration of structural specialization and adaptability in special or restricted habitats. The text is extensively documented with illustrations of specializations in structure. Much of this is drawn from information collected by the author and Dr. G. W. Crile, during several expeditions, prior to the death of the latter. The text, well illustrated with many new diagrams and pictures, combines the author's facility for description with a satisfactory amount of useful anatomical information to aid in the understanding of important structural changes from lower to higher levels of organization along with corresponding changes or adaptations of a functional nature. An interesting chapter, not usually found in texts covering this general subject, is the one concerned with anthropology in which the author sums up evidences for the several levels of structural and functional specialization that have culminated in man and the other anthropoid apes, and at the same time show the fundamental morphologic relationships of members of this group of Primates. In the final chapter the author presents some interesting concepts regarding levels of organization and function with respect to levels of organic evolution. The book is a useful reference for vertebrate zoology as well as for a premedical course in comparative anatomy.

FRED H. GLENNY

FLUCTUATIONS IN ORGANIC POPULATIONS IN RELATION TO SURVIVAL OF THE FITTEST

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Fluctuations were not discussed by Darwin or by Wallace, but some of the illustrations of the struggle for existence advanced by those authors doubtless were fluctuational phenomena. It is only in comparatively recent times that marked fluctuation in numbers has come to be recognized as a general, and as probably, indeed, a universal trait of organisms. It is unnecessary to cite here the evidence for the general occurrence of fluctuations, much information and keys to the literature being available, particularly in the works of Elton (see bibliography). Fluctuational phenomena, however, come frequently to the attention of every observant naturalist. Some of them, regular in periodicity, and, therefore, known as cycles, have attracted especial attention.

Quite without regard to fluctuational phenomena, critics weighing the postulated fortuitous nature of the variations upon which natural selection is supposed to act, and the ever present changes in environmental conditions, have pointed out the great improbability that selection could be maintained sufficiently in any certain direction to account for adaptation and evolution. Those factors do, indeed, render very unlikely the chance that natural selection could produce the steady advance needed to perfect adaptations, or to cause the orthogenetic evolution that is so commonly apparent.

With the variables mentioned in control, it would surely seem that selection must be for different reasons from time to time, while the facts relating to cyclically, or other severely, fluctuating populations are convincing that selection (if the term is justifiable at all) must be for different reasons at different phases of the cycle. When in the throes of the "die-off," for instance, survival of the fittest (if there is any such thing) would spare individuals most resistant to the parasite, disease, or other agency through which the "drop" or "crash" is effected. This crisis over, the fittest would be those that could best evade enemies of varying modes of attack, or those that could breed most rapidly and produce the largest number of viable young so as to reoccupy the depleted environment. As the population again tended toward the maximum, the fittest would be those that could live on a smaller quantity of food, or breed less rapidly so as not to increase the already threatening environmental pressure. Thus is each cycle (a period of about ten years in a number of cases, less in others), selection would necessarily be for a variety of qualifications, some of them of directly opposing tendencies. Environmental changes also would affect the character of the selection and, in the case of cyclic species, the organic environment, particularly other species involved in the cycle, is constantly changing. The numbers of predators and of buffers are as inconstant as those of the basic species and their potential effects on selection, therefore, are extensively variable. Unquestionably the circumstances of cyclic oscillations indicate orthoselection as impossible.

The light thrown upon fitness by the phenomena of irregularly fluctuating populations is much the same. Description of a case in point is here quoted from Taverner (1915, p. 20). "There is a certain definite maximum of population beyond which a species cannot go. We have many evidences of this. One of the most obvious was the case of the Bluebird in the winter of 1894-5 when this common species was almost wiped out in the south. For five years the species increased rapidly to normal population and then stopped short. As far as we can see no new factor was introduced, no enemy absent during the five years of growth was present in the sixth year, the food supply and birth rate seemed constant

throughout, but the increase was definitely and positively checked during the fifth year. It is obvious that a limit to the Bluebird population had been reached."

If we consider this case as an example of natural selection, we must assume that most of the young produced during the recovery period were fit and then conclude that most of those born afterward were unfit—a manifest absurdity. The bluebird case was a violent fluctuation, but all species fluctuate more or less, some of them both decidedly and periodically. The same difficulty of harmonizing the results with the principle of natural selection applies to all, namely, that it is unreasonable to suppose that a notably larger proportion of offspring produced during the upswing are fit than of those produced during other phases of the oscillation. As a matter of fact it is the absorbing capacity or fitness of the environment that rules. When the saturation point is reached, increase of the organisms stops; they are just as fit as before but there is no room for them.

Relatively rapid increase in population after a "low" shows that stress of competition has been relieved by the fluctuation. Success then comes to species in proportion to the degree to which they are freed from the force, natural selection, that is supposed to produce all fitness.

As noted, fluctuational phenomena do not augur well for orthoselection. When, therefore, we read that "Any advantage gained in one generation tends . . . to be accentuated in each succeeding generation . . . The advantage is thus cumulative . . . Mere differential numbers suffice," (Shull, 1936, p. 154), we can only conclude that the facts as to numerical oscillations have been ignored. When the "differential numbers" are not maintained, and this is true in all cases, "advantage" can not be maintained, much less accentuated.

Under natural selection theory, the tremendous drop in numbers shown by cyclic and other severely fluctuating species should act as a purifying fire; the race should be improved rapidly and with lasting effect. Instead, it breeds up to a maximum and is swept away again in exactly the same way as its ancestors have been over and over again. There are survivors but to say they are the fittest is a travesty for there has evidently been no improvement in fitness.

The "drop" in cyclic species comes at a time when they are at the height of their numbers, when they are most successful according to selectionist doctrine, and their members presumably at the top of their fitness. Nevertheless, the mortality often approximates totality. Under such circumstances, the slogan "survival of the fittest" seems a sardonic jest.

Argument that reduction in the number of individuals in fluctuations is "an important factor in causing uniformity in a species" ignores the countereffect of wide range. The organisms survive in colonies scattered here and there, each of which may be characterized by slight local variations. From a theoretical point of view this circumstance would promote diversity rather than uniformity. Both suggestions, however, fail to take into account that regardless of fluctuations, evolution is an orthogenetic, mass phenomenon.

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FURTHER STUDIES ON THE FAIRY SHRIMP POPULATIONS OF NORTHEASTERN OHIO

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Over a period of ten years, 1941-1950 inclusive, fairy shrimps have been collected from certain temporary pools and ponds in Portage, Summit, Stark, and Crawford Counties of Northeastern Ohio. Reports on the annual survey for the first six years have already been published (Dexter and Sheary, 1943; Dexter, 1943, 1946; Dexter and Kuehnle, 1948). The present paper summarizes studies of the past four years with additional information on annual fluctuations of populations of the fairy shrimp *Eubrachipus vernalis* (Verrill), its life history in four selected ponds, some ecological field notes and observations, and new records of geographic distribution. Acknowledgment is made to the trustees of the Research Fund of the Ohio Academy of Science for financial assistance in carrying out the field work, and to those who assisted with the field collections and contributed specimens for study. Each one is mentioned in the paper in connection with his particular contribution, but special thanks are due Mr. Paul Kuehnle for his coöperation in the study of Crawford County ponds over a period of seven years; Mr. Clarence F. Clark who has sent numerous specimens from time to time collected in the Western section of Ohio; and Mr. Frank W. Mead for his collections from Central Ohio.

REVIEW OF FIELD COLLECTIONS, 1947

In the season of 1947, 91 pools and ponds were studied (33 in Portage County, 14 in Summit County, and 22 each in Stark and Crawford Counties). Only 38 of these contained fairy shrimps. This was the poorest year for fairy shrimp populations in the ten year survey. While the month of January had much more than average precipitation, February and March were periods of severe drought which may have been partly responsible for the failure of fairy shrimps to appear in some pools. Precipitation in the late spring was far in excess of normal rainfall, but this came too late in the year to fill the pools and ponds when hatching normally occurs. While five new ponds inhabited with *E. vernalis* were discovered in 1947, there were no new appearances of this animal in stations already under observation. *E. vernalis* returned to nine stations after an absence of one year, but it disappeared from 24 ponds inhabited in 1946. Four stations had a pronounced increase in the abundance of fairy shrimps over the preceding year, and three had a marked decrease in abundance. In general, the fairy shrimp populations were not well developed in Portage and Stark Counties during this year, although Summit County seemed to have nearly its usual abundance. The span of the season in Crawford County was shorter than usual, which is probably accounted for by the dearth of precipitation during the early spring and the shallowness of most of the pools studied in that county. Abundant rainfall in the spring did not seem to compensate for the low precipitation in the late winter. Dr. William C. Stehr, of Ohio University, also found *E. vernalis* to be scarce in 1947 in ponds he has studied in Athens County. A single specimen only was collected from one of his ponds located east of Athens on Route 50 where they were previously common.

REVIEW OF FIELD COLLECTIONS, 1948

In the season of 1948, 95 ponds were investigated (27 each in Portage and Stark Counties, 11 in Summit County, and 30 in Crawford County). Twice as many ponds were found inhabited with *E. vernalis* this year over last year. A total of 75 contained populations. *E. vernalis* appeared for the first time in three of the

ponds which have been under investigation. Twelve new inhabited stations were added to the annual survey. Three of these were found for us by Miss Ruth Geib, now of Bethany College. In only two ponds populated in the previous year were the fairy shrimps absent. They returned to 18 stations after an absence of one year; to six after two years; and to one after an absence of three years. In addition they were considerably more abundant in 14 ponds, while they were less abundant in only two in comparison with the population of 1947. *Chirocephalopsis bundyi* was collected again in stations C7 and C18 for the first time in three years. As before, this species was not very numerous, a few specimens only being found among the collections of *E. vernalis*. The fairy shrimp season in 1948 did not begin generally until the last week of February. From that time on precipitation was unusually heavy, which undoubtedly was one of the principal reasons for the success of fairy shrimp populations that year. In general the season of 1948 was one of the best for fairy shrimps over a period of ten years. Dr. Stehr likewise found this season to be a very favorable one. He again collected numerous specimens from ponds which had not yielded specimens for several years previous.

REVIEW OF FIELD COLLECTIONS, 1949

In the spring of 1949, 104 ponds were visited (31 each in Portage and Stark Counties, 12 in Summit County, and 30 in Crawford County). In spite of nine ponds inhabited with *E. vernalis* added to the survey, the total number inhabited, 76, was virtually the same as in the preceding year. Fairy shrimps could not be found in 11 former stations, all of which contained specimens in 1948. However, they did return to the two which failed to yield specimens in 1948 after a number of years of being present. They also returned to one station after an absence of three years. Nine ponds contained considerably more, and seven contained many less than in the preceding year. *E. vernalis* was the only species collected in 1949. This year was a very early season for the fairy shrimps. Hatching took place in some ponds in the third week of December, 1948, although in some cases the first hatching was destroyed by subsequent freezing of the shallow pools to the bottom. New hatchings occurred after thawing and with increasing rainfall received by the pools in January. Precipitation was somewhat higher than average during the winter months. The deeper pools got off to an early start, and large mature specimens were found early in certain ponds. Mr. Paul Kuehnle, assisting the junior author in the study of the Crawford County stations, found four ponds out of eight to contain fully-developed and matured specimens on January 23. The largest specimen he had ever seen was collected on that date. Mr. Alfred Linscheid, of the Shaker Heights Schools, failed to find fairy shrimps in the Warrensville Swamp pond in the spring of 1949, although they were numerous there in previous years and returned again in 1950. Mr. Alton Yarian, instructor at Emerson Junior High School in Lakewood, also failed to collect fairy shrimps in 1949 from a pool at Rocky River where they had been common from 1945 to 1948. On the other hand, Dr. William A. Dreyer, of the University of Cincinnati, found the population of *E. vernalis* to be more abundant in a pond near Goshen which he has observed over a number of years. In 1947 he collected a single specimen from under a covering of ice. A number of specimens were obtained in 1948, and an abundance of material collected in 1949. The following year they were still common but not as abundant as in 1949. Populations of both *E. vernalis* and *E. serratus* studied by the senior writer in East Central Illinois were found to be most abundant in 1949 in a period of nine years of collecting. Only one pool known to contain fairy shrimps in the area sampled failed to develop them that year (Dexter, 1951).

REVIEW OF FIELD COLLECTIONS, 1950

In the tenth year of this survey, 110 pools and ponds were examined (31 in Portage County, 13 in Summit County, 32 in Stark County, and 34 in Crawford County). Altogether 89 of these contained fairy shrimps, including nine new sta-

tions added to the survey this year. The year 1950 proved to be second only to 1945 in general abundance and in the percentage of ponds containing these sporadic animals. It was the year of largest total number of ponds found inhabited. While they disappeared from six ponds since the previous year, they returned to seven others from which they were absent for one year, and to three ponds after an absence of three years. In addition, ten ponds had a greater abundance than in 1949, while only five had a smaller population. A small number of specimens of *C. bundyi* were again collected from station C18. The occurrence of this species in Geauga County is discussed in a later section of this paper. Again, the season of 1950 was a very early one for the appearance of fairy shrimps. They hatched out in many ponds in the third week in December, 1949, and were present for the follow-

TABLE 1
Summary of Field Collections

Year	1947	1948	1949	1950
Number on ponds studied	91	95	104	110
Number containing <i>E. vernalis</i>	38	75	76	88
Ponds drained or dry at time of examination.	0	S22	P1 (plowed over), P92 (drained), C21, C25	C20, C21, C22, C25
New appearance of <i>E. vernalis</i> in former stations.	0	C23, Cr16, Cr20	0	0
New stations containing <i>E. vernalis</i> .	P99, S22, C25, Cr21, Cr22	C26 thru C29, Cr23 thru Cr30	P100, C30 thru C34, Cr31 thru Cr33	P102, P103, S24, C35 thru C39, Cr34
Ponds from which <i>E. vernalis</i> disappeared since preceding year.	P17, P54, P89, P91, P92, P93, S2, C9, C10, C12 thru C17, C21, C22, Cr2, Cr3, Cr6, Cr10, Cr11, Cr13, Cr14	P8, C11	P37, P54, P55, P89, P91, P92, P95, S2, S4, C3, C21	C29, C4r, Cr21, Cr22, Cr25, Cr33
Return of <i>E. vernalis</i> after absence of one year.	P18, P50, P58, P90, P96, S3, S4, S11, C6	P17, P54, P89, P91, P92, S2, C9, C12, C13, C16, C21, Cr2, Cr3, Cr6, Cr10, Cr11, Cr13, Cr14	P8, C11	P37, P54, P55, P89, S2, S4, C3
Return of <i>E. vernalis</i> after absence of two years.	0	P23, P37, P42, P55, P90, P95	0	0
Return of <i>E. vernalis</i> after absence of three years.	0	C3	P30	C10, C14, C15
Increase in abundance of <i>E. vernalis</i> over preceding year.	P8, P79, C7, Cr9	P18, P43, S1, S3, S14, C2, C6, C18, C19, C25, Cr4, Cr8, Cr12, Cr22	P23, P50, P88, S5, C9, C12, C16, Cr11, Cr16	P42, P90, P96, C13, C30, C32, Cr8, Cr14, Cr24, Cr31
Decrease in abundance of <i>E. vernalis</i> over preceding year.	P43, S14, Cr4	S4, Cr1	P58, P96, Cr8, Cr14, Cr20, Cr24, Cr25	P17, P79, P80, Cr2, Cr3
<i>C. bundyi</i> found with <i>E. vernalis</i> .	0	C7, C18	■	C18

ing 20 weeks which is the longest season for *E. vernalis* recorded in this study. Winter precipitation this year was far in excess of the average. As in 1949, a mild winter permitted rapid development of these animals. On January 14 three mature males collected from station C8 measured 19, 24, and 25 mm. respectively. However, populations did not develop at a uniform rate in various ponds, as the tables show, nor did they retain their maximum abundance over a similar length of time. For example, *E. vernalis* had become scarce in stations P88 and P96 by April 2, 1950. On this date it was still abundant in certain pools visited in Summit and Stark Counties. Thirty ponds in the four counties studied contained fairy shrimps during all of the four years covered by this report. Seven ponds did not contain any fairy shrimps during this same period of time, although three of these (P40, P93, C17) did have a small population in past years. The majority of those

temporary ponds of water which have not yielded specimens after several years of investigation have been dropped from the survey. Two new stations in Portage County were discovered by Raymond C. Burger, a student at Kent State University, while engaged in field collecting near Edinburg. Mr. Alton Yarian has reported to the writers three ponds near Rootstown from which he has collected fairy shrimps at various times in past years. Because these were not accurately located, they were not visited by the writer, and specimens taken from these pools by Mr. Yarian are not now available. For these reasons they have not been included in the present survey. Table 1 summarizes the field collecting data for the years 1947-50.

During the spring of 1950 Mr. Richard L. Snyder, another student at Kent State University, was engaged in a field study of temporary pools in Stark County under the direction of the senior author. Three of the 56 ponds which he visited were found to be inhabited by two species of phyllopods. *E. vernalis* was common in two and rare in the third; one pond had in addition an abundance of *Lynceus brachyurus* Müller, a conchostracan phyllopod; the second pond had a small population, while the third yielded but two specimens of that species. This is the first record of the Conchostraca (claw shrimps) in Northeastern Ohio and the only time it has been encountered during the ten-year study of temporary pools in this region. Determination of the species was made by Dr. N. T. Mattox, College of Agriculture and Mechanic Arts, Mayaguez, Puerto Rico.

In the investigation of the Crawford County ponds in the spring of 1950, it was discovered by the junior author and his brother, Paul Kuehnle, that flood waters of the Olentangy River had washed out the fairy shrimp population from four ponds located on the banks of this river. While such flooding may eliminate a population from certain places, this may possibly be an agent in the dissemination of the species to other flood plain ponds farther downstream where mature individuals or the eggs may eventually be deposited. Ferguson (1939) suggested such an explanation for the disappearance of *E. vernalis* from pools on the flood plain of the Salt Fork River in Illinois studied by him and the senior writer. Dr. Marian Smith, University of Massachusetts, sent a record of finding a single fairy shrimp on May 26, 1945, near Northampton, Mass., in a shallow flood plain pool filled by overflowing waters of the Connecticut River. The pool was known to have dried out before flooding. Possibly the egg or the specimen itself had been washed in from another pool farther upstream.

COMPARISON OF THE LIFE HISTORY OF *E. vernalis* IN POND P88, 1947-1950

Pond P7 which had been studied throughout the entire fairy shrimp season in the years of 1943-1946 (Dexter, 1946; Dexter and Kuehnle, 1948) was destroyed during the summer of 1946. Weekly observations were continued, however, in pond P88 for the years 1947-1950. Visits were made nearly every week from the time water collected in this station and the subsequent hatching of fairy shrimps until they disappeared from the pond. A plankton-net sample and a dip-net sample were made at each visit; water temperature, pH, depth of water, and thickness of ice, if any, were recorded each time. Tables 2 and 3 summarize these physical data and measurements made on the fairy shrimp samples. A small number of specimens was taken, so as not to disturb the natural population any more than necessary. At certain times, however, such as very early or late in the season when they were few in number, all specimens encountered were taken. At other times a small sample was preserved which seemed to be representative of the size groups present in the pond. Earlier studies published by the writer on the life history of fairy shrimps were based upon measurements made on a sample which included only the first or oldest brood in the pond. In the present paper observations are reported and measurements have been made on all of the size groups which could be differentiated. Under certain conditions there is only one

major brood in a pond. This is true when the pond fills up with water early in the season. At other times, however, if a pond fills gradually, there is a succession of broods as the water reaches higher levels on the shore margin resulting in a succession of hatchings which may be spaced by days or weeks apart. Under these conditions a population will contain a wide range of different-sized individuals. Upon first hatching each brood can be distinguished from the older ones. Gradually, however, one group merges with another so that they cannot be distinguished. On several occasions we arbitrarily divided the specimens into size groups on the basis of previously distinguishable size groups rather than average together a wide range of sizes which would give a misleading average.

In 1947 pond P88 accumulated a few inches of water in the first week of January. On January 5, a plankton sample contained an abundance of copepods and ostracods, but no phyllopods were obtained. On January 12 a single fairy shrimp nauplius was collected in two inches of water under three inches of ice. Eggs were also obtained from the bottom sediments. Some of these eggs were in the process of hatching. The water remained very shallow until the first week of April when the pond became filled with four feet of water. At this time a new brood hatched as more eggs were now covered with water. A week later the pond was flooded and remained at high level for the remainder of the fairy shrimp season. Two distinct broods were present until the very last collection. As Coopey (1950) reported for *E. oregonus*, the rate of growth decreased noticeably at the time of maturity and the production of eggs. It seems to be generally true that during the time of egg production growth in total length is nearly suspended even though the shrimps continue to increase in length at a later time. This was also evident in the study of *E. serratus* published by Dexter and Ferguson (1943). Also, as was the case with that species, *E. vernalis* in pond P88 diminished in average size toward the end of its life history. Once again it is believed that the death of the oldest and largest specimens results in a smaller average with the persistence of younger and smaller specimens. The fairy shrimp season extended for 19 weeks, whereas in 1946 it lasted for 14 weeks, much of which time the population that year was decimated because of a long period of ice cover. The 1947 population extended to the latest date, May 25, on which *E. vernalis* has been found as a free-swimming animal in P88. The water was consistently cooler that season, and rainfall in April was much greater than normal, which facts undoubtedly explain the persistence of fairy shrimps to such a late date. Only once before was *E. vernalis* collected on that date. In 1943, pond P7 refilled on April 13 after drying out three weeks earlier, and a second generation of *E. vernalis* hatched which was collected up to May 25 (Dexter, 1946).

In 1948 the pond did not contain water until the middle of February. On February 22, hatching eggs and nauplii were found in shallow water under two inches of ice. Again, many unhatched eggs were recovered from the clay bottom. The depth of the water did not increase significantly for a month. On March 21, after the depth was nearly doubled, three distinct size groups were present, one of which was the result of a new hatching at the time of sampling. The pond failed to get more than 30 inches of water during the spring of 1948. The fairy shrimp population lasted until the first few days of May, a span of only 10 weeks, even though the depth of water was at its maximum at the end of the season and the temperature was not beyond the toleration limit for *E. vernalis*.

The next generation of *E. vernalis* hatched in the third week of December, 1948. Once again this appeared in just a few inches of water below a covering of ice. Within a week after hatching the pond froze to the bottom, destroying the fairy shrimps which had hatched up to that time. A thaw in the first week of January, 1949, permitted a second hatching. This brood survived even though the water remained shallow until the last week of February. At that time there were three broods present: the original hatching, a second one which appeared when the water level reached nearly a foot in depth, and a third one which appeared when the water

level reached a depth of one and one-half feet. Again the rate of growth diminished with the production of eggs, but later continued until a maximum length of 22 mm. was reached on April 10. Following this date the average size dwindled as noted in previous years. The second generation, and the only one to mature, existed

TABLE 2
Comparison of Life History of E. vernalis in Pond P88

1947	°C	pH	No. col- lec'd	Range in MM.	Aver. in MM.	Notes	1948	°C	pH	No. col- lec'd	Range in MM.	Aver. in MM.	Notes
1-12			1		1.0	3 in. ice over 2 in. water. Eggs just hatching.							
1-19	1.0	5.4	9	1.0-1.25	1.03	1.5 in. ice over 1.5 in. water.							
1-26	0.8	5.7	18	1.0-1.5	1.2	1.25 in. ice over 10 in. water.							
2-2	1.1		23	1.0-2.5	1.5	0.5 in. ice over 1.0 ft. water.							
2-11	1.1		22	1.5-5.0	3.1	8.75 in. ice over 6.5 in. water.							
2-16	0.5		9	2.5-5.8	3.8	8 in. soft ice over 7.25 in. water.							
2-23	0.5		20	3.0-6.3	4.8	8 in. ice over 7 in. water.	2-22	0.5		5	1.0-1.5	1.2	2 in. ice over 5.25 in. water. Eggs just hatching.
3-2	0.0		6		4.0	10 in. ice over 4 in. water.	2-29	0.5	6.8	4	2.25-2.75	2.5	Skim of ice. Greatest depth water 5.5 in.
3-9	0.0		2	3.0-7.0	5.0	8 in. ice over 5 in. water.	3-7	2.0	6.8	5	3.75-4.5	4.1	0.12 in. ice over 5 in. water.
3-16	0.5	5.9	12	6.0-9.0	7.3	5.5 in. ice over 5.75 in. water.				2	1.75-2.00	1.9	New hatching.
			1		3.0		3-14	1.5	6.3		4.0-6.5	5.3	3 in. ice over 6.5 in. water.
											2.25-3.0	2.7	
							3-21	14.5	5.9		12.0-14.5	13.7	15 in. water. New hatching with rise of water level.
											6.0-7.8 1.0-1.5	6.9 1.3	
3-30	0.5	5.6	15	4.5-9.3	7.2	7 in. soft ice over 9.5 in. water.	3-28	3.5	6.3		18.0-25.0 3.0-10.0	22.1 6.8	20 in. water. Larger group mature with developing eggs and mature coloration. Immature group still pinkish in color.
4-6	12.2	5.8	14 1	10.25-14.0	11.5 4.5	4 ft. water.	4-4	10.0	6.2	2 many	11.0-14.0	22.0 13.2	20 in. water.
4-13	9.5	6.0	5 many	9.0-16.0 4.0-6.0	12.3 5.1	5 ft. water. Abundance of recently-hatched larvae.	4-11	11.3	5.9	2 many	14.0-17.0	22.5 15.8	20 in. water. All females with egg sacs.
4-20	8.0	6.0	3 many	17.0-22.0 6.0-12.0	19.5 9.3	5 ft. water. First brood mature.	4-18	12.0	5.6	2 many	21.0-26.0 13.0-17.5	23.5 15.6	30 in. water.
4-27	10.5	6.1	4	18.0-22.0 8.0-16.25	19.3 13.9	5 ft. water. Females of first brood with eggs. Second brood still immature.	4-25	19.5	5.9	1 many	12.0-17.0	24.5 15.6	30 in. water.
5-4	13.6	6.1	2 10	20.8-21.5 13.0-18.5	21.1 15.3	5 ft. water.	5-2	15.0	5.9	5	13.5-17.0	14.9	30 in. water. Last collection of season.
5-11	11.7	6.3	1 12	9.5-16.5	19.0 13.6	4 ft. water.							
5-18	17.2	5.9	13	11.0-19.5	18.7	4 ft. water.							
5-25	19.2	6.0	3		19.0	5 ft. water. Last collection.							

TABLE 3
Comparison of Life History of *E. vernalis* in Pond P88

1948	°C	pH	No. col- lec'd	Range in MM	Aver. in MM	Notes	1949	°C	pH	No. col- lec'd	Range in MM	Aver. in MM	Notes
12-19	0.5		10	1.0-1.5	1.2	0.5 in. ice over 8.5 in. water. Metanauplii abundant.	12-19			1		1.0	Several puddles in cow tracks 1-2 in. deep from rain of 12-18-49.
12-26						1.75 in. ice; frozen to bottom.	12-26			1		1.5	Scattered puddles 1-3 in. deep. Skim of ice.
1949 1-2	0.0		6	1.0-1.5	1.2	2.75 in. ice over 2 in. water. Second hatching.	1950 1-2	9.0	5.4	64	1.0-2.25	1.7	3.5 in. water. Many in process of hatching.
1-9	6.5	5.3	3	1.0-1.2	1.1	5.5 in. water. Hatching still in process.	1-8	1.0	5.2	30	1.0-1.75	1.3	0.75 in. ice over 7 in. water. Hatching still in process.
1-16	9.0	5.9	20	1.5-2.5	2.1	5.0 in water.	1-15	1.5	5.8	40	1.2-4.5	2.0	0.5 in. ice over 14 in. water.
1-23	1.7	6.0	19	1.2-4.0	2.8	0.5 in. ice over 4 in. water.	1-22	0.5	5.4	41	1.2-5.5	2.9	2 in. ice over 19 in. water.
1-30	2.2	5.2	12	1.0-1.4	1.2	2.1 in. ice over 11 in. water. New hatching only collected.	1-29	6.0	5.8	58	1.0-11.25	5.6	2 ft. water. Continuous hatching has produced wide range of sizes.
2-6	2.5	5.4	5	3.9-6.4	5.2	4 in. ice over 9 in. water.	2-5	3.0	5.9	10	4.2-10.25	7.6	1.5 in. ice over 2 ft. water.
2-13	3.0	5.3	18	5.7-8.8	7.2	1 in. ice, melting at edges, over 13.5 in. water.	2-12	3.0	6.0	26	4.5-12.0	7.9	0.25 in. ice over 2 ft. water. Mature specimens 18 mm. in length collected from P43 and P96.
			11	1.1-3.0	2.4								
2-20	7.5	5.7	9 20 8	11.0-17.0 3.0-7.8 1.0-2.5	12.9 4.4 1.6	18 in. water.	2-19	2.0	5.9	15 5 4	11.0-19.0 5.5-7.0 1.0-1.2	12.4 6.2 1.2	3 ft. water. Largest specimens mature, but egg sacs not yet developed.
2-27	5.5	5.8	5 20 3 1	13.0-17.0 4.5-11.0 2.8-3.5 1.0	15.2 6.8 3.1 1.0	0.25 in. ice over 19 in. water.	2-26	3.0	5.9	21 6	12.0-18.0 10.2-8.0	14.8 8.7	4 in. ice over 3.5 ft. water.
3-6	6.0	5.9	7 62 1 3	14.0-19.0 7.0-12.5 8.0 5.0 1.0	15.9 8.9 8.0 4.0 1.0	20 in. water. Largest females with egg sacs.	3-5	2.5	5.9	26	7.0-18.0	13.8	5.5 in. ice over 3 ft. water. Continuous variation in size.
3-13	4.0	5.9	7 25 3 1	13.5-17.0 7.8-12.0 6.3-6.5 4.3	15.0 10.0 6.3 4.3	1 in. ice over 20 in. water.	3-12	2.5	6.1	29	9.5-18.6	15.3	2.5 in. ice over 3.5 ft. water. Egg sacs developed. Adult coloration.
3-18	4.0	6.0	2 20 17 1	11.0-14.5 5.0-10.5 8.4 4.0	17.0 12.0 8.4 4.0	0.25 in. ice over 20 in. water. Size groups not distinct.	3-17	3.5	6.2	22	11.25-19.2	16.3	2.25 in soft ice in center over 3.5 ft. water. Egg sacs fully developed.
3-27	14.5	5.9	1 29 2 1	12.0-19.0 9.0-9.5 9.3 6.5	22.0 15.5 9.3 6.5	21 in. water.	3-26	4.0	6.2	22	14.0-22.3	18.7	4.5 ft. water.
4-3	6.5	5.9	20 11 10 9	17.0-21.3 10.0-16.0 7.5-9.0 8.6	18.2 12.3 8.6 8.6	21 in. water.	4-2	7.0	7.4	10	14.0-23.5	19.9	5 ft. water.
4-10	8.5	5.7	1 11 11 18	17.0-20.5 11.0-15.5 7.0-11.0 9.3	22.0 18.0 13.0 9.3	21 in. water.	4-9	9.0	7.4	24	16.0-25.8	19.4	5 ft. water.
4-17	13.0	5.5	13 10	16.5-20.0 11.0-15.0 12.8	17.8 12.8 12.8	22 in. water.	4-16	6.5	7.4	19	18.5-25.0	21.5	4.5 ft. water.
4-24	8.5	5.2	16 12	15.0-17.5 12.0-14.5 13.6	16.0 13.6 13.6	22 in. water.	4-23	12.5	7.4	20 1	17.0-24.0 9.5	20.5 9.5	4.5 ft. water. Adults gray in color.
5-1	16.0	5.2	12 5	16.0-19.0 12.0-13.5 12.7	17.5 12.7 12.7	21 in. water. Last collection of season.	4-30	9.5	7.4	13	19.5-26.0	23.1	4.5 ft. water.
							5-7	15.5	7.4	9	22.0-28.0	25.9	4.5 ft. water. Last collection of season.

over a period of 17 weeks. As in the previous two years the water level was near its seasonal maximum and the temperature was not excessive at the time the fairy shrimps disappeared for the year.

The population of the winter of 1949-1950 closely paralleled that of the previous winter in nearly all respects. However, the first hatching was not destroyed by freezing in spite of very shallow water again this season. After the water level ranged over two feet in depth, three distinct broods could be distinguished, but these soon merged with overlapping ranges so as to lose their identity. The pond was flooded to its maximum depth of five feet in April, but the fairy shrimps disappeared at about the same time as in the preceding year, during the first week of May. Apparently they do not live long after reaching their maximum development in spite of the presence of ample water and temperatures well below the threshold of tolerance. Nevertheless, the life span of a single generation for 20 weeks recorded this year is the longest observed in this study over a period of seven years. Ferguson (1939) estimated that the life span of *E. vernalis* in Ontario may be as long as six months. Coopey (1950) found the life span of *E. oregonus* to extend for 23-25 weeks in the state of Washington. These observations of Ferguson and Coopey were made farther north in one case and at higher altitude in the other than the present studies carried out in Northeastern Ohio. Undoubtedly these topographic differences with their associated climatic differences serve to modify the pattern of the development of invertebrate animals such as fairy shrimps. Some years the fairy shrimp population is limited by either the drying out of the temporary pools, water temperatures which go beyond the threshold of tolerance, or both. During the four years covered by this report those factors were not involved, since the water level increased in local ponds during the spring months of 1947-1950 rather than decreased as was the case in 1943-46. Also, water temperatures remained cool during the presence of fairy shrimps over the past four years. Fairy shrimps were more abundant in 1949 and 1950 in ponds P88 and P8 than for some years previous. The fact that these ponds dried out completely in the summer of 1948 and 1949, which they seldom do, may have been partly responsible for the larger population the following winters. It is known from experimental evidence (Weaver, 1943) that drying of the eggs stimulates hatching. The senior writer is conducting experiments on this problem with several species of phyllopods.

COMPARISON OF THE LIFE HISTORY OF *E. vernalis* IN PONDS C7, C19, AND C23 IN 1950

While the preceding section compares the life history of *E. vernalis* in one pond over a period of four years, it was thought desirable to study several ponds during a single season in order to compare the development of this fairy shrimp in different places and in different habitats simultaneously. Four ponds in Stark County were selected for that purpose. Table 4 presents the results of the observations. Since one pond, C8, had a very small population of fairy shrimps in 1950, the results from that station are not included. While all of the other three show a somewhat common pattern, it is clear that local conditions modify the life history of *E. vernalis* to a significant degree. Specimens had already attained a size up to 16 mm. in station C23 and up to 20 mm. in C19 by the time metanauplii appeared in pond C7. Water did not accumulate in C7 as early as it did in the other two ponds. At the time C7 filled in the fourth week in January, with subsequent hatching of fairy shrimps, new hatchings also occurred in C19 and C23 although the water level in the latter two was not noticeably higher. Fairy shrimps lasted until April 1 in one pond and persisted for at least four weeks later in the other two. In the case of C19 the fairy shrimp season extended over a period of 11 weeks, while in C7 it extended for 13 weeks. Since it is not known when hatching occurred in C23, the seasonal span cannot be determined, but it was for more than 16 weeks. The development of *E. vernalis* in pond P88 in Portage County began earlier and extended later than any of the Stark County stations. It is also clear that on or

about the same date specimens of the same species of fairy shrimp in different habitats and localities have reached a total length of wide diversity. In addition to comparisons shown on table 2, the following have been noted. Miss Frances J. Hindley collected *E. vernalis* on March 23, 1947, near Creston, Ohio, which were fully developed and mature, while those found in pond P88 at that time were only about one-half developed. On April 6, 1947, the shrimps in P88 had reached a maximum of 14 mm. and were still immature and orange-pink in color. On that same day in pond P96 they were up to 18.25 mm. in total length, were

TABLE 4

Comparison of Life History of E. vernalis in Ponds C7, C19, and C23 in 1950

Date	C7				C19				C23			
	No. collected	Range in MM.	Aver. in MM.	Notes	No. collected	Range in MM.	Aver. in MM.	Notes	No. collected	Range in MM.	Aver. in MM.	Notes
1-14					9	2.5-7.0	4.8	1.5 ft. water.	11	4.0-11.0	7.5	2 ft. water.
1-22					1 7		10.0 3.0	2 in. ice over 1.5 ft. water.	20 23 7		16.0 9.5 2.8	2 in. ice over 2 ft. water.
1-28	26		2.5	Skim of ice over 3 ft. water.	1 many	1.5-9.0	20.0 3.8	Skim of ice over 1.5 ft. water.	14 15 53	11.0-14.0 7.0-8.0 1.5-5.0	12.5 7.5 3.3	Skim of ice over 2 ft. water.
2-4	28	2.0-7.0	4.5	1.5 in. ice over 3 ft. water (on 2-5).	2 many	3.0-12.0	15.0 7.5	1 in. ice over 1.5 ft. water.	11 5 46		15.0 10.0 4.0	1 in. ice over 2 ft. water. Large females with eggs.
2-14	69	2.0-8.0	4.0	2.5 ft. water.	5 many	15.0-20.0 10.0-15.0	17.5 12.5	1.5 ft. water.	26 71	12.0-20.0 5.0-8.0	16.0 6.5	2 ft. water.
2-18	25	4.0-8.0	6.0	Skim of ice over 2.5 ft. water.	304 38	12.0-21.0	16.5 10.0	Skim of ice over 1.5 ft. water.	56 94	12.5-21.0 8.0-12.0	16.5 10.0	Skim of ice over 2 ft. water.
2-26	5 17	3.5-7.0	10.0 5.3	4 in. ice over 2.5 ft. water.	37	16.0-18.0	17.0	4 in. ice over 1.5 ft. water.	14 54	18.0-20.0 8.0-14.0	19.0 11.0	4 in. ice over 2 ft. water.
3-4	4 27	9.0-12.0 4.0-7.0	10.5 5.5	3 in. ice over 2 ft. water.	79 115 10	15.0-20.0 12.0-16.0	17.5 14.0 12.0	5 in. ice over 1.25 ft. water.	14 7 45	18.0-20.0 12.5-15.0 8.0-12.0	19.0 13.5 10.0	5 in. ice over 2 ft. water.
3-12	29	6.0-12.0	9.0	2 ft. water.	207	14.0-20.0	17.0	1 in. ice over 1.25 ft. water.	47 80	15.0-21.0 8.0-13.0	18.0 10.5	1 in. ice over 1.5 ft. water.
3-18	9	7.0-14.0	10.5	2 ft. water.	52	12.0-22.0	17.0	1.25 ft. water.	28 many	13.5-22.0 8.0-13.0	17.5 10.5	1.5 ft. water.
4-1	2 17	15.0-17.0 6.0-10.0	16.0 8.0	1.5 ft. water.	5		25.0	1 ft. water. Last collection.	52 35	15.0-17.0 8.0-10.0	16.0 9.0	1 ft. water.
4-16	63 71	14.0-20.0 7.0-10.0	17.0 8.5	1 ft. water.					59	10.0-22.0	16.0	1 ft. water.
4-29	40	10.0-20.0	15.0	2 ft. water. Last collection.					3 7	19.0-21.0 7.0-11.0	20.0 9.0	1.3 ft. water. Last collection

mature, and had the characteristic coloring of adults (females, bluish-gray; males, light green). It has been mentioned earlier that on January 14, 1950, three males collected from C8 measured 19, 24, and 25 mm. respectively, whereas fairy shrimps collected from P88 on the following day were not over 4.5 mm. in length.

GENERAL AND ECOLOGICAL NOTES AND OBSERVATIONS

In previous reports it has been pointed out that the sex ratio of *E. vernalis* collected from ponds in Northeastern Ohio averaged 1 male to 1.5 females. However, it was noted that specimens collected from Stark County had a ratio of 1:0.5 (Dexter, 1946). With the study of ponds in Crawford County, beginning in 1944, it was discovered that here again males predominated in the collections with a sex

ratio of 1:0.75. In the spring of 1947 another sample of specimens from Crawford County gave the same ratio. In 1948 populations from Stark County showed a sex ratio of 1:0.88; and in Crawford County, a ratio of 1:0.84. In 1950 the ratio of the three ponds in Stark County which were studied throughout the season (C7, C19, C23) was determined to be 1:0.75, 1:0.85, and 1:0.83 respectively, based upon a sample of over 1200 specimens. At least in those ponds which have been sampled from Stark and Crawford Counties, males predominate over females in abundance, whereas in Portage and Summit Counties female specimens have been somewhat more abundant.

The pool in Portage County (P42) which had *E. vernalis* introduced experimentally in the spring of 1943, and which was found to contain a small number of fairy shrimps two years later (Dexter and Kuehnle, 1948), was discovered to have another small number in 1948. None was found during the two intervening years. In 1949 a total of 15 specimens was collected there; the following spring there was an abundant population. In spite of this pond having been plowed in the fall of 1943, fairy shrimps succeeded in becoming established although it required seven years for a sizeable population to develop.

Occasionally fairy shrimps are collected which contain a large number of attached organisms. On January 22, 1950, for example, most of the specimens collected from station P88 were covered with a dense population of a stalked protozoan (*Epistylis* sp.) which was especially abundant attached to the appendages of the fairy shrimps. On March 17, 1950, and again nine days later, most of the specimens collected from the same pond were covered with a growth of green algae. Again these attached organisms were largely concentrated on the appendages.

Sometimes fairy shrimps are found in a surprisingly small amount of water. Specimens of *E. vernalis* have been collected from a number of pools containing no more than a few quarts of water. This is especially true, of course, toward the end of the fairy shrimp season during those years when the temporary pools and ponds dry out at an early date. At such times fairy shrimps can be found in water no more than an eighth of an inch in depth. On one occasion *E. vernalis* was found in station S18 on April 6, 1946, still alive and kicking about on the surface of the wet mud in the last stages of drying out. In contrast to such limitation of water, fairy shrimps are occasionally reported from bodies of water which are somewhat permanent. It has already been pointed out that the ponds P8 and P88 do not dry out completely each year, but these and similar ponds which contain fairy shrimps do have a dry margin during the summer season so that there is ample opportunity for many of the fairy shrimp eggs to be dried before hatching. Kenk (1949) reported a similar situation in which both *E. vernalis* and *C. bundyi* have been collected from a permanent pond. Dr. Ann H. Morgan of Mt. Holyoke College has reported to us her experience in collecting fairy shrimps over a period of years in a spring-fed, permanent forest pond near South Hadley, Massachusetts. Mr. L. Wayne Wilson has sent specimens of *E. vernalis* from a permanent pond at Moorefield, West Virginia. Two unusual situations of this nature have come under our own observation. At C7 there is a small pool at the edge of the temporary pond which is spring-fed and contains water the year around; much of the water in the pond is derived from this spring. Fairy shrimps are usually most abundant in this pool although they do not occur there any earlier as a rule than they are found in the temporary pond itself. Plankton samples from this pool in the fall season have failed to produce specimens or larvae of fairy shrimps. Very possibly the shrimps hatch from the flooded temporary basin and then swim in to the adjoining pool where they become concentrated in very large numbers. The writers have never seen a greater density of fairy shrimps than they have found in this pool during certain years. It might be added that plankton samples taken in pond P88 during the summer and fall seasons likewise were devoid of larval stages of fairy shrimps. In spite of the persistence of water in these

two stations, and some others like them, the fairy shrimp eggs do not hatch in this region until the middle of December. Eggs of fairy shrimps normally are subjected to conditions of drying and freezing before hatching. While it has been shown that the eggs can be hatched experimentally (Weaver, 1943) without drying and/or freezing, the eggs of *E. vernalis* in temporary pools of temperate America do undergo those conditions and probably few eggs of these fairy shrimps hatch in a natural situation without having undergone either drying or freezing. In the spring of 1950 *E. vernalis* was collected in large numbers from a permanent pond (S24) in Summit County. Because of the permanent nature of this pond it had not been examined for fairy shrimps in previous years. In the summer of 1949 it was drained and remained dry until the following winter. When this filled to capacity in the spring months, it developed a large population of *E. vernalis*. Unfortunately, it is not known exactly when these crustaceans made their appearance. If they had been present in earlier years, this could be explained by the dry margin around the pond which is present during dry summers.

An unusual situation has been observed at station P55, a shallow woodland pool in the trough of an abandoned canal. At high water level two adjoining depressions are connected by a short, narrow channel. As the water level drops the two become separate pools. The occurrence of fairy shrimps has been uniform for both portions over a period of years, as one might expect. Shrimps were not found in either in 1941-43, 1946-47, and 1949. They were numerous in both in 1944; common in both in 1945; common in the west half in 1948, but the more shallow east half had dried out before a sampling was made. In 1950 they were numerous in the west half, but absent in the east portion even though both contained a normal amount of water and were connected by shallow water at the time of sampling.

Mr. Frank W. Mead, a graduate student at Ohio State University, collected a sample of *E. vernalis* in water of unusual temperature for this species. He collected his specimens from a small temporary pool some eight feet in diameter with a depth of four to five inches located near McComb in Hancock County. At the time of collecting on May 5, 1950, the water was 25°C.

The pond near Middlefield in Geauga County which has been reported with a population of *Chirocephalopsis bundyi* (Dexter and Kuehnle, 1948) was re-examined in 1948-1950. In April of 1948 the Donaldson family found this species to be common. The following year Miss Grace Donaldson found an abundant population of this species in the same woodland pool, and in addition found some specimens of the same species in a nearby pond from which they were recorded for the first time. In the spring of 1950 the senior writer accompanied by Miss Donaldson again found an abundant population in the original pool and a single specimen in the second one. Fairy shrimps have not been numerous in the second pond since discovery. However, it should be pointed out that the single specimen collected was taken somewhat late in the fairy shrimp season. Again, *C. bundyi* was the only species found in these two pools, and they remain the only ones known in the state of Ohio in which this species of fairy shrimp occurs by itself. Dr. Charles A. Dambach, Chief of the Wildlife Division, Ohio Department of Natural Resources, informed us of having observed fairy shrimps in a number of pools in Hambden Township of Geauga County some 25 years ago. Further investigation of this county is needed.

NEW RECORDS OF GEOGRAPHICAL DISTRIBUTION

Over the past four years a number of biologists have kindly sent specimens collected in various sections of Ohio. Nine new county records have been established by these collections, largely through the field work of Frank W. Mead. In addition, records have been made from 13 new localities in counties where *E. vernalis* has already been reported. Table 5 gives a digest of all of these. Figure 1 presents a map of Ohio showing the localities from which fairy shrimps have been known to occur up to the present time.

TABLE 5

New Records of Fairy Shrimps Collected in Ohio

County	Collector	Location	Species	Notes
I. NEW COUNTY RECORDS				
Columbiana	Irene Weeks, Salem High School.	Perry Township	<i>E. vernalis</i>	From temporary orchard pool, Spring, 1948. Known since 1945; none found in 1949.
Pickaway	Frank W. Mead, Ohio State University.	Wayne Township, near Circleville.	" "	Woodland pools and Calamus Swamp, 3-25-48, 3-24-49, and 4-22-50.
Madison	" "	Between Chenoweth and Mt. Sterling.	" "	Grassy ditch, 3-25-49.
Union	" "	Darby Township, 2 miles east of Chuckery.	Unknown	Roadside ditch, about 1 ft. deep. Specimens not saved.
Fairfield	" "	Walnut Township, section 8.	<i>E. vernalis</i>	Woodland pool, 4-10, 22-48; 3-14-49.
Licking	" "	Lima Township, section 5.	" "	Collected 3-21-50.
Knox	" "	2 miles northwest of Centerburg.	" "	Buttonbush swamp, 3-27-49.
Morrow	" "	3 miles south of Johnsville.	" "	Collected 4-15-50.
Hancock	" "	1 mile south of McComb.	" "	From small and very shallow pool in open woods, 5-6-50.
II. NEW RECORDS FROM COUNTIES PREVIOUSLY REPORTED				
Wayne	Frances J. Hindley, Creston High School.	Near Creston	<i>E. vernalis</i>	Collected 3-23-47.
Ashland	Kenneth Chiavetta, Ohio State University.	Mohican State Forest, Loudenville.	" "	Collected 5-2-47.
Athens	William C. Stehr, Ohio University.	2 miles east of Athens.	" "	From open woodland pasture pool, 3-18-48. First record known from this pond after many years of examination.
	Henri C. Seibert, Ohio University.	4 miles north of Athens.	Unknown	Collected 3-24-50. Specimens lost.
Clinton	Frank O. Hazard, Wilmington College.	Vernon Township.	<i>E. vernalis</i>	Collected 3-10-45.
Franklin	Frank W. Mead, Harold Tvedt, Kenneth Chiavetta, Douglas Stancombe, (students at O.S.U.)		" "	Many specimens have been collected from numerous pools of various types throughout the county, 1947-1950.
Delaware	Frank W. Mead, Ohio State University.	Near Olive Green.	" "	From open woodland pool, 3-27-49.
Marion	" "	Near Waldo	" "	Collected 3-27-49, from pool 10-14 in. deep.
Crawford	" "	Holmes and Bucyrus Townships.	" "	Collected 5-3, 5-50, from one pool in each township.
Seneca	Frank J. Ligas, Heidelberg College.	5 miles east of Tiffin.	" "	From woodland pool; first week of April, 1950.
Wood	Eugene Dastman, Ohio State University.	Liberty Township	Unknown	Collected in March, 1947.
Hardin	Clarence F. Clark, Ohio Dept. of Natural Resources.	Taylor Township, 5 miles southwest of Kenton.	<i>E. vernalis</i>	Collected 4-10-48.
Auglaize	"	Salem Township, section 32.	" "	Collected 4-9-48.
Shelby	"	1 mile west of Sidney.	" "	From woodland pool, 4-25-50.

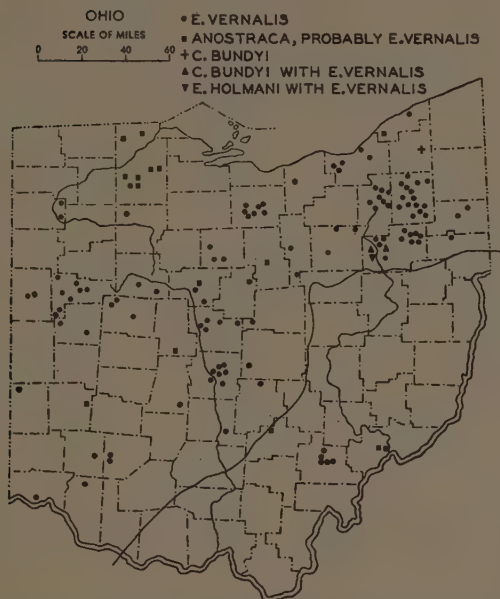


FIGURE 1. Location of all known records of Anostraca in Ohio. Each symbol includes all records within a radius of one-half mile. It will be observed that the great majority of records known to date are from the glaciated portion of the state.

SUMMARY AND CONCLUSIONS

The continuation of an annual survey of fairy shrimp populations in Portage, Summit, Stark, and Crawford Counties of Northeastern Ohio in 1947-50 has led to the following results:

1. The season of 1947 was the poorest one in the ten years of this survey, with only 38 pools from a total of 91 investigated inhabited with *Eubbranchipus vernalis*. A winter drought is believed to be partly responsible for the dearth of records.

2. Twice as many ponds (75) were found inhabited in 1948 as in the preceding year. The species returned to 25 ponds after an absence of one to three years, and was generally more abundant than in 1947.

3. The season in 1949 was an early one, hatching beginning in the third week of December, 1948. Although it did not yield as large a percentage of ponds inhabited with *E. vernalis*, the total number was virtually the same and the general abundance was somewhat greater than in the previous year. Fairy shrimps were fully developed in some ponds by the third week of January.

4. In 1950 a total of 89 ponds contained *E. vernalis*, the largest number found in any one year. Altogether, 110 stations were examined. The percentage of ponds inhabited with this fairy shrimp and the general abundance were second only to 1945. Again, the season began with hatching in the third week of December, and it extended for 20 weeks, the longest one observed in ten years. A table summarizes the most significant fluctuations observed in 1947-50.

5. Thirty ponds contained *E. vernalis* each of the four years covered by this report.

6. *Chirocephalopsis bundyi* was again collected with *E. vernalis* from two stations in 1948, for the first time in three years, and was collected from one of those stations in 1950.

7. The first record of a conchostracan phyllopod is made for Northeastern Ohio. *Lyneus brachyurus* Müller was found in three temporary pools in Stark County among populations of the anostracan *E. vernalis*.

8. Tables compare the life history of *E. vernalis* in one pond (P88) for four consecutive years and in three ponds (C7, C19, C23) for the season of 1950.

9. *E. vernalis* has been collected as late as May 25 in Portage County.

10. Fairy shrimps which hatch early in very shallow pools are destroyed when the pools freeze to the bottom.

11. Several broods are produced by the gradual raising of the water level which reaches the eggs at various time intervals.

12. *E. vernalis* does not persist long as a free-swimming animal after completing its development even though water of a favorable temperature remains in the pond.

13. Local conditions produce variations in the development of *E. vernalis* populations in ponds having a somewhat different physical environment and geographic location.

14. On the same date, the size and abundance of *E. vernalis* may vary greatly from one pond to another.

15. Males are more abundant than females in collections of *E. vernalis* from Stark and Crawford Counties, although the opposite is true in collections from Portage and Summit Counties.

16. *E. vernalis* introduced into a new pond experimentally developed an abundant population in seven years.

17. Stalked protozoans and green algae are known to become attached to fairy shrimps in great abundance.

18. *E. vernalis* has been found living in extremely small amounts of water as well as in semi-permanent ponds.

19. *E. vernalis* has been collected from water with a temperature as high as 25°C.

20. *C. bundyi* was found to be common in 1948-50 in a pond in Geauga County where it was discovered in 1946, and was found in small numbers in an adjacent pond in 1949-50.

21. Nine new County records and 13 new locality records for the occurrence of *E. vernalis* in Ohio are reported. A map indicates the location of all known records of fairy shrimps from 42 of the 88 counties of Ohio.

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TWO NEW SPECIES AND ONE SUBSPECIES OF NORTH AMERICAN BUPRESTIDAE

(COLEOPTERA)

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Hesperotripis mirabilis albopennis n. subsp.

(Fig. 1)

Male.—This subspecies differs from *H. mirabilis mirabilis* Knull by having a wide diagonal white band on each elytron.

Length 3.9 mm.; width 1.3 mm.

Holotype male labeled Blythe, Riverside Co., California, July 19, 1950. Two male paratypes from Santa Rosa Mts., Riverside Co., California, July 4, 1949, elevation 3,900 ft. All specimens collected by D. J. and J. N. Knull.

Chrysobothris kidaigensis n. sp.

(Figs. 2, 3, 4, 5, 6 and 7)

Male.—Narrow, elongate strongly shining; above bluish black, head, anterior margin, median line and sides of pronotum in front, five spots on each elytron, first five segments of antennae femora and anterior and middle tibiae brilliant metallic green, ventral surface greenish black.

Head deeply concave in front; clypeus slightly emarginate in middle, surface finely punctate on front, punctures coarser on vertex, transversely rugate at base, median carina on vertex; antennae compact, third segment longest, longer than second, outer segments compact, longer than wide.

Pronotum much wider than long, widest back of front, sides strongly expanded in front, then subparallel to near middle, converging back to middle; anterior margin emarginate, base emarginate each side with well developed median rib, disk convex, a slight depression in front of scutellum, surface glabrous, transversely rugulate. Scutellum small, triangular.

Elytra near base wider than widest part of pronotum, widest behind middle, sides subparallel back of humeri, expanded back of middle, then strongly convergent to rounded serrulate apices; margins serrulate from in front of middle; disk convex, with two depressions at base on each elytron, dark background densely punctate, metallic green areas unevenly punctate.

Abdomen beneath densely and finely punctate, a callosity at side on each segment; last visible sternite deeply emarginate; side margins not serrulate, surface in middle with granulate undulating area, punctures same as on other segment at sides. Prosternum strongly ribbed, widely rugate in front, rest of area coarsely punctured. Anterior femur with well developed tooth not serrulate on outside. Anterior and middle tibiae uninate, the former strongly dilated toward apex, posterior tibia straight. Genitalia as figured.

Length 4.7 mm.; width 3 mm.

Female.—Middle of front dark, same color as background. Last visible sternite crispate; surface lacking granulate undulating surface of male.

Holotype male, allotype and paratypes collected near Mission, Hidalgo Co., Tex., April 7, 1950, by D. J. and J. N. Knull.

This species runs near *C. apicalis* Lec. in Fisher's key. Mr. G. B. Vogt kindly compared a specimen with material in U. S. National Museum and states that it is close to *C. warreni* Thoms., but differs by being smaller, elytra and pronotum more coarsely and densely punctate and posterior apical margins more finely dentate.

Knull, J. N., Ohio Jour. Sci. 57: 303, 1957.

Fisher, W. S., U. S. Dept. Agr. Misc. Pub. 470: 1-275, 1942.



1. *Hesperorhipis mirabilis albopennis* n. subsp., ♂. (Line equals 1 mm.) *Chrysobothris*
hidalgoensis n. sp. 2. Adult ♂. (Line equals 5 mm.) 3. Clypeus. 4. Last visible sternite,
♂. 5. Last visible sternite, ♀. 6. Dorsal view, ♂ genitalia. (Line equals 1 mm.) 7. Ven-
tral view of No. 6. 8. *Agrilus ohioensis* n. sp., dorsal view, ♂ genitalia. (Line equals 1 mm.) 9. Ventral view of No. 8.

Agrilus ohioensis n. sp.

(Figs. 8 and 9)

Male.—Resembling *A. otiosus* Say in form and size; dorsal surface dark bronze, head, antennae and sides of pronotum metallic greenish blue; ventral surface blackish bronze.

Head convex; surface granulose on front, pubescent on lower half, densely, finely punctate on vertex, antennae serrate from the fourth segment.

Pronotum wider than long, widest about middle, base and apex about equal in width; sides subparallel in front, convergent back of middle; when viewed from side, marginal and submarginal carinae joined near base; anterior margin strongly sinuate, median lobe broadly rounded; basal margin trisinate; disk convex, with two shallow median depressions and a strong lateral depression each side about middle; hind angles carinate; surface finely granulose, feebly transversely strigate. Scutellum granulose, transversely carinate.

Elytra at base wider than base of pronotum; sides subparallel near base, constricted in front of middle, expanded back of middle, then converging to rounded, serrulate apices; disk slightly flattened, sutural margins strongly elevated back of middle, a basal depression on each elytron; surface densely imbricately punctate.

Abdomen beneath with middle portion of first two segments concave; surface densely, finely punctate, pubescence short. Prosternum granulose, pubescence moderate, not extending along median line; prosternal lobe broadly rounded, with slight emargination in middle. Tibiae all armed with a distinct tooth on inner margin at apex. Posterior tarsi shorter than tibiae, first segment about as long as following segments together. Tarsal claws similar on all feet, cleft near middle, outer tooth acute, inner tooth broader, turned inward at tip, touching opposite tooth.

Length 4.5 mm.; width 1.1 mm.

Female.—Unknown.

Holotype male labeled Delaware Co., Ohio, June 19, 1950, D. J. and J. N. Knull collectors. One paratype from same locality June 22, 1950, and one labeled Greene Co., Ohio, June 1, 1950, all collected by the author and his wife.

This species would run to *A. atricornis* Fishr. in Fisher's key.³ However, it can be separated by the obtuse apex of median lobe of male genitalia and by the densely placed punctures on ventral surface of outer lobes.

Type material in collection of the author.

³W. S. Fisher, U. S. Nat. Mus. Bul. 145: 1-347, 1928.

CHEMISTRY LIBRARY PURCHASED BY UNIVERSITY OF WISCONSIN

The University of Wisconsin has recently purchased one of the major collections of books on chemistry and related fields, the Dennis I. Duven chemistry library. The collection includes the Latin alchemical works of Geber, Lull, Dee, Kelley, and Maier; the most significant writings of the medical period by Paracelsus, Glauber, Boerhaave, and others; books by Becker and Stahl, founders of the phlogiston theory; and writings of the period when the foundations of modern chemistry were laid as represented by important French, English, and German chemists.

Sections of the collection which would be unusual assets to the University are: "The Crell Journals," published in the latter part of the 18th century and devoted exclusively to pure and applied chemistry. All six of the journals, more than 70 volumes, are in the collection, a total matched only by the Library of Congress. "Essays on the Accademia del Cimento," which represent some of the basic foundations in physical science of a period when Italian science was foremost. "Histories of Chemistry," a collection published during the past century by noted authors, now out of print.

A NEW SPECIES AND NEW GENUS OF GALERUCINAE (CHRYSOMELIDAE: COLEOPTERA)

JOHN A. WILCOX¹

Department of Zoology and Entomology, The Ohio State University, Columbus 10

Schaeffer in 1906, described *Cneorane* (?) *acaciae* from Brownsville, Texas. He stated at the time that it did "not agree exactly with description of *Cneorane* by Chapuis." He placed *acaciae* in *Cneorane* because he did not observe terminal spurs on the tibiae, this character separating *Cneorane* from related American genera. Specimens of *acaciae* in The Ohio State University collection do have definite, though small, spurs on all tibiae. With this character in mind it seems that Schaeffer's species fits the description of *Malacorhinus* Jacoby very well.

There are at present two North American species included in *Malacorhinus*. These two, *M. maculatus* (Lec.) and *M. nigrescens* Schffr. appear out of place in association with *acaciae* and Jacoby's species. They differ by lacking spurs on anterior tibiae and by possessing an incision in lateral margin of the elytra. The elytral incision also occurs in *Androlyperus* Crotch. *M. maculatus* was originally described in *Androlyperus* and is probably much more closely related to that genus than to *Malacorhinus*. However, *Androlyperus* is described as lacking tibial spurs while *maculatus* and *nigrescens* possess spurs on middle and hind tibiae.

Since *M. maculatus* and *M. nigrescens* do not fit any known genus I hereby propose the name *Malacamerus* to be used for a new genus to contain them. *Androlyperus maculatus* Leconte, 1883, is designated genotype.

Following is a key to North American genera which are closely related to *Malacorhinus*. This group may be defined as having appendiculate tarsal claws, anterior coxal cavities open, elytral epipleura well defined, first segment of hind tarsus not longer than second and third together, form not strongly convex, and not entirely metallic blue.

KEY TO THE GENERA

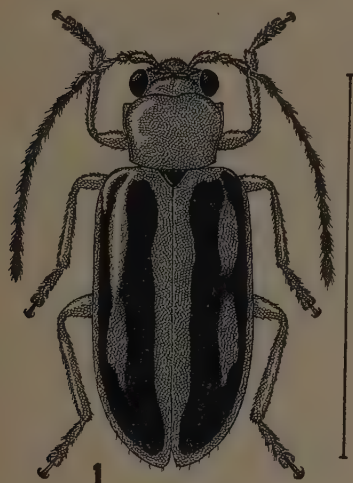
1. All tibiae lacking terminal spurs.....2
At least middle and hind tibiae with spurs.....4
2. Anterior coxae separated by prosternum which is visible between.....3
Prosternum not visible between coxae, coxae contiguous.....*Cneorane* Baly
3. Pronotum black; male with lateral margin of elytra entire.....*Pseudoluperus* B. & H.
Pronotum pale; male with lateral margin of elytra incised.....*Androlyperus* Crotch
4. Front tibiae without terminal spurs.....5
Front tibiae with spurs.....6
5. Middle tibiae not notched; lateral margin of elytra incised in male; antennae with 11 segments.....*Malacamerus* n. gen.
Middle tibiae deeply notched on inner side near apex; lateral margin of elytra entire in male; antennae with 10 or 11 segments.....(male) *Phyllecthrus* Lec.
6. Anterior coxae narrowly separated by prosternum; pronotum at base nearly as wide as elytra.....*Exora* Chev.
Anterior coxae contiguous, prosternum not visible between them.....7
7. Epipleura narrow, about as wide at base as middle of middle tibiae; pronotum usually with broad depression.....(female) *Phyllecthrus* Lec.
Epipleura distinctly wider at base than middle of middle tibiae; surface of pronotum evenly convex.....*Malacorhinus* Jacoby

Malacorhinus Jacoby

Malacorhinus Jacoby, 1887, Biologia Centrali Americana, Coleoptera 6(pt. 1):582.

Body elongate oval or oblong; palpi rather robust; antennae filiform, sometimes serrate in male, third segment distinctly longer than second; prothorax subquadrate, narrower at base than

¹Present address: New York State Museum, Albany, N. Y.



JAW

1. *Malacorhinus knullorum* n. sp., ♂.
2. *M. knullorum* n. sp., dorsal view of ♂ genitalia.
3. *M. knullorum* n. sp., lateral view of ♂ genitalia.
4. *Malacamerus maculatus* (Lec.) ♂.
5. *Malacorhinus acaciae* (Schffr.), ♂.

Line equals 4 mm. Drawings from specimens in The Ohio State University collection.

at apex; elytra generally widest at middle, often with a median lateral fovea; epipleura broad at base and extending below the middle; all tibiae with terminal spurs; first segment of posterior tarsi about as long as the following two together; claws appendiculate; anterior coxal cavities open; prosternum not visible between the coxae.

Jacoby designated his *Diabrotica foveipennis* as genotype and included eighteen other Central American species with it.

KEY TO THE NORTH AMERICAN SPECIES OF MALACORHINUS JACOBY

1. Legs and ventral side black or dark brown; elytra each with basal and apical black spot (fig. 5).....*acaciae* (Schffr.)
- Legs and ventral side yellowish-brown; elytra each with two black longitudinal stripes, more or less confluent (fig. 1).....*knullorum* n. sp.

Malacorhinus acaciae (Schaeffer)

Figure 5

Cneorane (?) *acaciae* Schaeffer, 1906, Brooklyn Inst. Mus. Sci. Bull. 1:246.

Elongate oval, slightly depressed; shining, brownish-yellow, each elytron with basal and elongate apical spot black, these spots often confluent. Head shining, finely punctulate, transversely impressed between eyes, subcarinate between antennae; labrum feebly emarginate; antennae reaching beyond the middle of elytra, first segment stout, clavate, slightly curved, longer than third, third slightly longer than second, not as long as fourth, fourth to eleventh subequal. Pronotum wider than long, much narrower at base than elytra, widest at apical third; lateral margin feebly arcuate, front angles prominent but not acute, hind angles not prominent; surface shining, sparsely punctulate. Elytra elongate, widest at middle, sides feebly arcuate; brownish-yellow, each with a basal black spot and an elongate spot on apical third, these two may be confluent; surface very finely alutaceous, finely, irregularly punctulate, glabrous. Ventral surface sparsely punctate and pubescent; third segment of maxillary palpi shorter and stouter than second, fourth slightly longer than third, conical, acute at tip. Male elytra broadly impressed near side margin from umbone to a little below middle.

Length 4-5 mm., width 1.7-2.1 mm.

This species has been taken at Brownsville, Texas from May to July. The food plant is recorded as *Acacia flexicaulis*.

M. acaciae (Schffr.) seems to agree very closely in form to *M. foveipennis* Jac. which is the type species of the genus. It is very similar in appearance to *M. guatemalensis* Jacoby, differing from that species in size and the presence of median lateral fovea on the male.

Malacorhinus knullorum n. sp.

Figures 1, 2, 3

Elongate oval, sides of elytra nearly parallel; yellowish-brown; elytra each with two black stripes which may be coalescent. Head entirely pale, alutaceous, impunctate, a single hair just behind each eye; interocular distance half the width of head across the eyes; tubercles limited behind by a deep depression extending from posterior margin of eye arcuately across head; inter-antennal carina short, feebly convex. Antennae three quarters the length of body, basal three segments pale, rest black, second segment short, third nearly twice as long as second, nearly as long as fourth, fourth to eleventh subequal, fourth segment of male slightly angulate, of female straight. Pronotum half again as wide as long, much narrower than elytra at base, wider at apex than at base; sides nearly straight, anterior margin slightly emarginate, posterior margin arcuate; surface evenly convex, shining, finely, sparsely punctulate. Scutellum black, shining, impunctate. Each elytron three times as long as wide, humeri prominent; epipleura wide, concave at base, extending to apical angles; margins and suture broadly pale, a poorly defined median stripe also pale, the rest black; surface finely alutaceous, moderately shining; punctation moderate, close; glabrous. Palpi robust, fourth segment slightly longer than third, conical, acute at tip; under side entirely pale, pubescent with scattered, rather long hairs. Aedeagus with long narrow tip, recurved at base; orificial plate long, narrow, sides parallel.

Length 4-6 mm., width 2-3 mm.

Holotype: ♂ collected by D. J. and J. N. Knull at Oak Creek Canyon, Arizona (Coconino County), August 15, 1938. Allotype and four paratypes (1 ♂ and 3 ♀♀), same data. All these specimens are deposited in The Ohio State University collection. Also two paratypes (1 ♂ and 1 ♀) in the writer's collection, same data.

The two sexes are very similar in form and color. The female is usually larger and has fourth antennal segment normal. The pale median area on the elytra is more definite in female so each elytron has two black stripes. In male it usually consists of two small pale spots.

This species looks a little out of place in *Malacorhinus*. It resembles in form some *Phyllecthrus*, however it has the characters of tibial spurs and contiguous coxae in common with the species Jacoby placed in *Malacorhinus*. It is more parallel, more depressed, and lacks the median lateral fovea of typical members of that genus.

Malacamerus n. gen.

Malacorhinus Jacoby, Horn, 1893, Trans. Amer. Ent. Soc. 20:120.

Form elongate oval or oblong; palpi rather stout, terminal segment conical, acute at tip; antennae slender, third segment longer than second, shorter than fourth; pronotum subquadrate, broader than long, widest at apical third, surface without depressions; elytra oval, broader in male, lateral margin in male with deep incision at apical angle surrounded by long pubescence, epipleura broad at base, extending to incisure or apical angle in female; anterior coxal cavities open; prosternum extending narrowly between coxae; tarsal claws appendiculate; anterior tibiae without terminal spurs, middle and hind tibiae with spurs; first segment of posterior tarsi as long as following two together.

Genotype *Androlyperus maculatus* Leconte. This name is selected because the two species form a group which was considered to be a part of *Malacorhinus*.

KEY TO THE SPECIES OF MALACAMERUS N. GEN.

1. Elytra red, each with a black spot at basal third and one at apical third (fig. 4),
Elytra black or brown with suture and margins reddish.....
- | | |
|--|-----------------------------|
| | <i>maculatus</i> (Lec.) |
| | <i>nigrescens</i> (Schffr.) |

Malacamerus maculatus (Lec.)

Figure 4

Androlyperus maculatus Leconte, 1883, Class. Coleop. N. Amer., p. 349; Leconte, 1884, Trans. Amer. Ent. Soc. 12:28. *Malacorhinus maculatus* (Lec.), Horn, 1893, Trans. Amer. Ent. Soc. 20:121. *Malacosoma cimex* Allard, 1889, Bull. Soc. Ent. Belg. T 33:68.

Color red; head, scutellum, antennae, legs, meso- and metasternum, last abdominal segment and two spots on each elytron black. Head smooth, shining; frontal tubercles flat, sharply delimited; clypeus with very strong, broad, median carina and a circular alutaceous depression on each side; front below eyes depressed and alutaceous. Pronotum shining, with scattered, very fine punctures; lateral margin sinuate, front angles prominent, swollen, hind angles obtuse; posterior margin evenly arcuate. Elytra impunctate, very finely alutaceous in male, smooth and shining in female; surface around incision of male strongly depressed and pubescent with long white hairs, margin strongly sinuate behind incision. Outer segments of antennae coarsely punctate; second segment small, one third the length of third, third and fifth subequal, fourth longer. Prosternum sparsely pubescent, meso- and metasternum more densely so, shining. Last ventral segment of male truncate, sinuate at apex, surface broadly foveate; of female evenly rounded, convex.

Length 7-9 mm., width 3.3-4.2 mm.

This species occurs in southern California. The types in the Leconte collection are from San Diego. A series in The Ohio State University collection was taken by D. J. and J. N. Knull in the Santa Rosa Mountains (Riverside Co.).

Malacamerus nigrescens (Schffr.)

Malacorhinus nigrescens Schaeffer, 1906, Brooklyn Inst. Mus. Sci. Bull. 1:246.

Color red; clypeal region, femora, disc of elytra, and metasternum black; tibiae, tarsi, and apices of antennal segments brownish. Head smooth, shining; a fine, transverse impression

between eyes; front not carinate. Second antennal segment small, third longer but not so long as fourth, fourth as long as first. Prothorax narrower at apex than at base, front angles prominent, swollen, hind angles distinct; surface shining, finely, irregularly punctate. Elytra black with reddish margins and suture, the black more intense at base and apex; depression surrounding elytral incision tuberculate. Last ventral segment of male with a narrow, deep median fovea.

Length 5 mm.

The type specimen in the Schaeffer collection was taken in Utah.

The author has not seen any specimens of this species. Schaeffer in his description suggests, because of the varying intensity of black on the elytra, that specimens may occur in which the elytra are red with black basal and elongate apical spots.

The May Number of the OHIO JOURNAL OF SCIENCE will contain

THE GLACIAL BORDER —
CLIMATIC, SOIL, AND BIOTIC FEATURES

A Symposium of the Ecological Society of America held at Columbus, Ohio, September 13, 1950, during the Meeting of Biological Societies sponsored by the American Institute of Biological Sciences.

E. LUCY BRAUN, *Chairman*

VEGETATION AND CRYOPLANATION.....	<i>Hugh M. Raup</i>
PLEISTOCENE FROST ACTION NEAR THE BORDER OF THE WISCONSIN	
DRIFT IN PENNSYLVANIA.....	<i>Charles S. Denny</i>
THE FOSSIL RECORD NEAR THE GLACIAL BORDER.....	<i>J. E. Potzger</i>
THE POSSIBLE ROLE OF MICROCLIMATE.....	<i>John N. Wolfe</i>
ANIMALS OF THE GLACIAL BORDER.....	<i>Edward S. Thomas</i>
PLANT DISTRIBUTION IN RELATION TO THE GLACIAL	
BOUNDARY.....	<i>E. Lucy Braun</i>

Copies of the May Number containing the papers in the Symposium may be obtained from the Business Manager of the JOURNAL at \$1.00 each.

FOUR NEW SPECIES OF MEXICAN *CICADELLA* (HOMOPTERA: CICADELLIDAE)

DWIGHT M. DeLONG AND ROBERT F. RUPPEL

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Collections of Mexican leafhoppers to date have shown only four species which seem to belong to the genus *Cicadella* and all are apparently new species. One of these, *cordoba*, resembles superficially the European *vittata* Linn. The other species, *scarlatina*, *circula* and *cochlea*, have elytra which are indented at the apices somewhat like *stellulata* (Burm.) but are otherwise quite different. Because of this wing condition combined with a flattened body and an elongate produced flattened head, they may even be ranked as a subgenus of *Cicadella* and the name *Scinda* is proposed with *scarlatina* as the type.

Cicadella cordoba n. sp.

Figure 1

Resembling *vittata* Linn. in form and appearance but with different coloration and distinct male genitalia. Length 3.5–3.75 mm.

Vertex produced, blunt, rounded at apex, longer in female than in male. Median length in female about three-fourths and in male about one-half as long as the basal width between the eyes.

Color mostly dark brown or smoky, marked with pale spots. Vertex with basal portion usually brown or smoky, apical portion paler. Face pale, some shade of yellow. Pronotum and scutellum usually dark brown unmarked. Elytra brown or smoky with a small pale spot on commissure just beyond middle of clavus and another spot just posterior to apex of claval vein. A large pale spot is on the costal margin and is crossed about two-thirds its length by the outer antepical cross vein which is brown in color.

Genitalia: Female seventh sternite with a strongly produced posterior margin forming a bluntly pointed apex. Male plates long and rather slender, the apical half narrow. Styles slender, elongate, the apical portion broadened to form a foot-like portion with the pointed toe turned outwardly. Male aedeagus erect with a broad erect anterior portion and a slender erect aedeagus shaft which bears a pair of rather long slender terminal fingerlike processes. The pygofer bears a long, tapered caudal spine on the basal margin.

Holotype male, allotype female and male and female paratypes collected at Cordoba, Veracruz, Mexico, November 20, 1924, by Dr. Dampf. These were swept from ferns in shade in the Barranca of the Rio San Anton.

Cicadella scarlatina n. sp.

Figure 2

A flattened leafhopper with a wing venation like *stellulata* (Burm.) with a flattened, produced head, distinct coloration and genitalia. Length 4 mm.

Vertex bluntly angled, dorsoventrally flattened, median length about three-fourths the basal width between the eyes. Elytra with a rounded notch at about the middle of the apical portion. Head and body decidedly depressed, dorsoventrally flattened.

Color yellowish marked with red and brown. Vertex yellowish with a narrow brown line above margin of vertex extending along margin between eyes. Pronotum with the anterior half reddish, the posterior half pale. Elytra and scutellum marked with concentric circular reddish bands. A red band extends from base of elytra on either side across basal half of scutellum. Another reddish band extends from about the middle of corium on each side diagonally forward across the clavus just posterior to the scutellum. The apical third of clavus is red, forming an

ovate spot when the elytra are folded together. The area surrounding this reddish spot is white. The apical portion posterior to clavus is infuscated or smoky, the veins are orange red. Face with a black line extending between eyes above antennae. Face yellow below this line and white above.

Genitalia: Female seventh sternite with the lateral margins rather strongly produced, posterior margin concavely sloping each side to form a median produced, blunt, lobe-like apex. Male plates elongate, styles long and slender with a broadened, foot-like apex, the outer margin pointed. Aedeagus composed of three erect processes. The median process is broad and serrate at apex. The posterior process is formed by the aedeagus shaft bending back upon itself at apex and curving anteriorly and dorsally to form the longest of the three processes. In caudal view the apical blade of this process is broadened then tapers to a pointed apex. The pygofer bears a short, erect, caudal spine on the caudodorsal margin just beneath the anal tube.

Holotype male and allotype females collected at Lagunas de Cimpola, Mor, Mexico, October 4, 1941, paratype males collected at Orizaba, Veracruz, October 17, 1941, by DeLong, Caldwell, Good and Plummer. Paratype female collected at Laguna de zempoala Mor, October 21, 1945, by Plummer, DeLong, Hershberger and Elliott.

Cicadella circula n. sp.

Figure 4

Superficially resembling *scarlatina* but with distinct coloration and genitalia. Length, male, 3 mm.

Vertex produced, blunt at apex, one-fourth wider between eyes at base than the median length.

Color: White marked with red. Vertex white with a pair of black, elongate, diagonal dashes at apex and a rather narrow, broken reddish, transverse band between the anterior margins of the eyes. Pronotum banded. The anterior half is red, the posterior half is white. There is a transverse white spot at middle just back of vertex and the central half of the white area extends forward into the red area on the posterior portion. Basal portions of scutellum and basal portion of elytra red, due to a transverse band which curves posteriorly on caudal margin and reaches the costa at one-third its length. Posterior half of claval vein broadly red, joined to a broad red transverse band which extends across clavus at about its middle and another just before apex of clavus. These form a round white spot on commissure just behind middle of clavus. There is a diagonal black mark on costa just beyond middle which is directed caudally. The apical third of the elytra embrowned with a few white areas. Face white with a pair of black spots just above antennae and a spot either side next the base of each eye on the inner margin.

Genitalia: Male plates with a pointed, twisted spine like apex. Styles rather narrow, elongate, foot-like, the toe pointed outwardly. Aedeagus rather short, produced dorsally at base then tapered to a curved portion which bends ventrally then back upon itself, forming a long, slender blade like apical whip which extends almost to the dorsal wall of the pygofer chamber.

Holotype male collected at Necaxa, Pue, October 27, 1945, by Stone, DeLong, Hershberger and Elliott.

Cicadella cochlea n. sp.

Figure 3

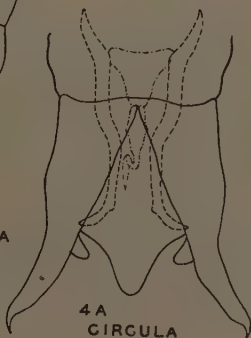
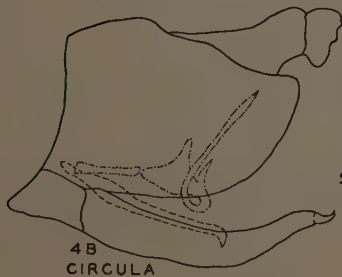
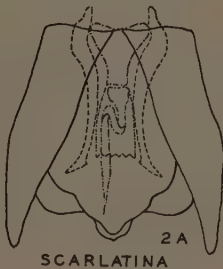
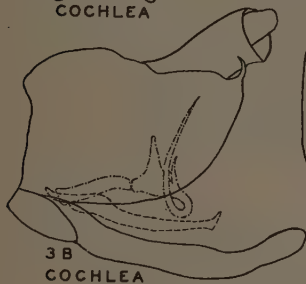
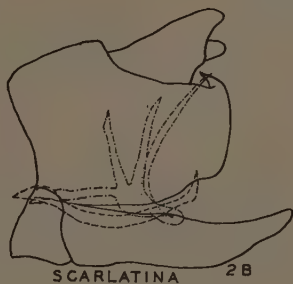
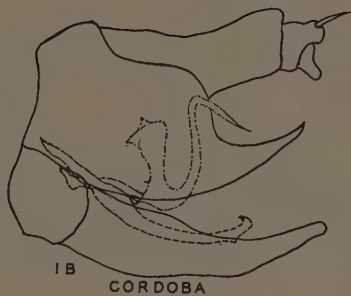
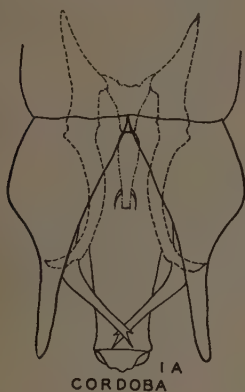
Resembling *circula* in form but with distinct coloration and male genitalia. Length 3 mm.

Vertex bluntly produced, almost one-fourth wider between eyes at base than median length.

Color: White, vertex and face without specific dark markings. Pronotum white with a dark

EXPLANATION OF PLATE

- 1A. *Cicadella cordoba*, ventral view male genitalia; 1B—lateral view of male genitalia;
1C—ventral view of female caudal portion of abdomen; 1D—caudal view of male aedeagus.
2A. *Cicadella scarlatina*, ventral view of male genitalia; 2B—lateral view of male genitalia;
2C—ventral view of female caudal portion of abdomen.
3A. *Cicadella cochlea*, ventral view of male genitalia; 3B—lateral view of male genitalia.
4A. *Cicadella circula*, ventral view of male genitalia; 4B—lateral view of male genitalia.



brown band on posterior portion, the front margin of which curves forward to the anterior margin at about the middle of each eye. The brown band covers the basal half of the scutellum and the basal tips of the elytra. With this exception, the elytra are white on the basal half and dark brown to black on the apical half with white areas between the apical veins. Veins yellow, apical veins black.

Genitalia: Male plates tapered and bluntly rounded at apex. Styles elongate, narrow, foot-shaped at apex with a pointed toe extending outwardly. Pygofer with a narrow, curved spine extending dorsally and anteriorly from the caudodorsal extremity. Aedeagus similar to *circula* with a dorsally produced basal portion beyond which the aedeagus is narrowed to form a produced anterior portion which is ventrally curved, then is recurved to form a dorsal, apical whip which is long and slender. A spine arises at about the middle on the dorsal margin of the aedeagus shaft.

Holotype male collected at Necaxa, Pue, October 27, 1945, by Stone, DeLong, Elliott and Hershberger.

Principles of Genetics. E. W. Sinnott, L. C. Dunn, and Th. Dobzhansky. 4th ed. 1950. McGraw-Hill Book Co., Inc., New York, 18. xiv+505 pp. \$5.00.

This fourth edition of a famous text book of genetics differs from the decade old third edition in several respects. The sequence of presentation has been changed to give a more systematic unfolding of the ideas and concepts of genetics. The text has been increased by about 100 pages and has been completely rewritten, although some passages reveal their parentage in the third edition. Most noticeable changes are in the chapters dealing with quantitative inheritance, cytogenetics, population genetics, and physiological genetics.

The chapter on quantitative inheritance now achieves a greater unity between the biometrical tools and the genetical raw material. The chapters on linkage, recombination, genetic maps, chromosomes, cytological maps and chromosomal aberrations rank among the best accounts available in introductory texts. The former single chapter on population genetics has been expanded in the new edition to three chapters showing the imprint of one of the authors (T. D.). Similarly, four chapters on physiological genetics where there were three before show the influence of another of the authors (L. C. D.). Recent developments in the genetic study of bacteria, fungi, protozoa, and man are introduced in appropriate places throughout the text.

This book appears to be the best book available for the instruction of advanced undergraduate and beginning graduate students in the fundamental principles of genetics.

E. L. GREEN

Wildlife Management. Ira N. Gabrielson. 1951. The Macmillan Company, New York 11. xii+274 pp. \$4.50.

The author fills the most serious gap in the field of wildlife management with a practical rather than sentimental approach to the subject. This book is written primarily with a view to the more important aspects of management from the administrator's point of view. Few men in the field are so completely competent to discuss the varied problems of wildlife management and its administration as is Dr. Gabrielson, who has had more than 20 years of practical field experience and served for 12 years as Chief of the U. S. Fish and Wildlife Service before becoming President of the Wildlife Management Institute. While the author does not dogmatically solve many of the highly important and somewhat controversial problems persisting in this field, he does discuss them openly and makes serious suggestions which may lead to their eventual solution. Many popular, widespread beliefs which have deterred progress in wildlife management are treated as only Dr. Gabrielson can treat such subjects. It is the first domestic publication which deals with the broadest problems of management facing the peoples of North America, and which is not based on foreign premises or experiences. It is written from a truly *American* point of view in a highly readable style, and as a result is a great relief from the traditional influences of European plans or problems.

FRED H. GLENNY

COLORED GRAIN SELECTION BY SIX PEN-RAISED PHEASANTS

FRED H. GLENNY

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Recent studies on the effect of color, as a factor in the selection or repellant of birds, have been somewhat inconclusive or contradictory. Kalmbach (1943) used colored grains as a basis for determining the level of "non-acceptance" by quail and "acceptance" by rodents in an effort to establish criteria for the dyeing of poisoned baits. Later Dambach and Leedy (1948, 1949) experimented with colored grains as a means of repelling pheasants, in an effort to reduce "pulling" of corn.

Kalmbach's studies can hardly be said to be entirely conclusive, since the cereals employed are not generally regarded as normal diet for the birds under observation. Furthermore, acceptance of colored grains "beyond the color-perception range for the avian eye" could be justified on the basis of simple conditioning. While this may be a factor, the writer does not hold this explanation to be altogether satisfactory, since we do not know the absolute range of color perception in the birds, despite the fact that visual acuity in birds is known to be high.

Dambach and Leedy were unsuccessful in establishing a wholly satisfactory repellant in the case of pheasants. While several methods were employed, neither colored grains nor those with noxious odors were completely successful in repelling or greatly reducing losses by pheasant "pulling" of sprouted corn and corn seedlings.

Seven vegetable dyes were used to treat the grain (corn) used in this investigation, and in addition, normal, untreated corn was used. Six adult pheasants (3 males and 3 females) were employed during the course of the test periods. The birds were kept in a small greenhouse which provided roosting facilities, and at the same time afforded adequate room in which to move about. In addition, there was considerable dry soil available for "dusting" and scratching. It would appear that some grit was also available.

Three dishes of grain (whole corn kernels) were placed on the ground, and the position of these dishes changed daily so that on no two consecutive days were any combinations of colors in exactly the same position. On the second day of the test, a wooden "flat", commonly used in starting plants, was used as a corollary to the main tests. Bowls "A" and "B" were replenished daily to provide 100 kernels each of four different colors of corn for consumption. The volume of corn in bowl "C" was approximately equivalent to that of corn in either bowl "A" or bowl "B"; the volume of untreated corn in bowl "C" was checked daily, and the amount of corn used by the birds replaced. The actual number of kernels of corn was not counted for bowl "C", but measurement by volume was made each day. The wooden tray, which contained 10 grains of normal (untreated) corn and 10 grains of each of the seven colored (treated) corn kernels, was also checked and the consumed kernels replaced daily.

The results of these tests, noting the *daily, period total*, and *average daily consumption* of the various colored grains in each bowl, are in table 1.

OBSERVATIONS

In table 1, the data collected during the two testing periods (Feb. 17-Feb. 25 and Mar. 2-Mar. 6, 1949) are arranged to show the daily consumption of untreated and dyed corn, in grains per day for six pheasants.

TABLE 1

Daily consumption of untreated and dyed corn, grains per six pheasants, February 17 to 25 inclusive, and March 2 to 6 inclusive.

Treatment	NUMBER OF DAYS OF TEST (2/17-2/25, 1949)										(3/2-3/6, 1949)							
	1	2	3	4	5	6	7	8	9	Total	Aver- age	1	2	3	4	5	Total	Aver- age
BOWL A:																		
Tartrazine Yellow	27	11	99	90	31	94	96	84	95	627	69.7	92	90	53	45	100	380	76.0
Amaranth Red	31	0	75	7	5	5	17	8	26	174	19.3	17	22	2	1	19	61	10.3
Brilliant Blue	32	0	4	5	10	60	37	16	78	242	26.9	26	53	13	30	55	177	35.4
Nigrosine	30	0	4	6	4	35	24	9	6	118	13.1	17	56	28	30	100	231	46.2
Total	420	11	182	108	50	194	174	117	205	1161	129.	152	221	96	106	274	849	169.8
BOWL B:																		
Untreated	25	99	100	91	28	35	66	41	30	515	57.2	83	37	86	70	42	318	63.6
Sunset Yellow	13	6	45	37	15	4	59	18	13	210	23.3	44	2	32	10	3	91	18.2
Erythrosine	7	4	38	6	6	3	31	25	24	144	16.0	38	3	57	22	37	157	31.4
Guinea Green	8	8	6	11	90	18	44	15	26	226	25.1	26	0	25	1	4	56	11.2
Total	53	117	189	135	139	60	200	99	93	1085	121.6	191	42	200	103	86	622	124.4
BOWL C:																		
Untreated	100%	100%	100%	100%	80%	100%	40%	95%	100%		90.5%	25%	100%	50%	40%	40%		51.0%
WOODEN FLAT:																		
Untreated		10	10	10	10	10	9	9	10	78		10	10	10	10	10	50	
Tartrazine Yellow		9	10	10	10	10	10	10	10	79		10	10	10	10	10	50	
Sunset Red		3	8	10	10	10	10	10	10	71		10	10	9	10	10	49	
Erythrosine		1	5	10	10	10	2	10	10	58		10	10	10	10	10	50	
Amaranth Red		2	8	10	10	10	10	8	9	67		10	7	10	10	10	47	
Guinea Green		3	5	10	10	10	10	9	9	66		10	10	9	10	10	49	
Brilliant Blue		4	7	10	10	10	10	10	10	71		10	10	10	10	10	50	
Nigrosine		0	1	10	10	10	10	4	9	54		10	10	9	9	10	48	
Total		32	54	80	80	80	71	70	77	544		80	77	77	79	80	393	

At the end of nine days, four days of feeding only normal, untreated corn followed, before returning to the use of colored corn for a period of five days.

Table 2 summarizes the corn consumption in bowls "A", "B", and "C" for both the nine day and five day periods, with respect to high and low corn consumption, and average daily consumption. The average daily consumption can be read as either numbers of kernels of corn consumed or as percentage of kernels of corn consumed (number consumed: number available).

DISCUSSION AND CONCLUSIONS

It will be noted from the above observations that there may have been some learning during the first testing period, since there was an average increase of 7.74 grains of colored grains taken per day during the second testing period (above the average daily consumption in the first period.)

Assuming that some learning did occur during the first period, it would appear to be with respect to "general acceptance" of colored grains, rather than with

TABLE 2

Daily corn consumption for six pheasants, with respect to high and low consumption.

	9 DAY PERIOD			5 DAY PERIOD		
	High	Low	Average	High	Low	Average
Amaranth Red.....	75	0	19.3	22	1	10.3
Erythrosine.....	38	3	16.0	57	3	31.4
Sunset Yellow.....	59	4	23.3	44	2	18.2
Tartrazine Yellow.....	99	11	69.7	100	45	76.0
Normal Green.....	100	25	57.2	86	37	63.6
Guinea Green.....	90	6	25.1	26	0	11.2
Brilliant Blue.....	78	0	26.9	55	13	35.4
Nigrosine.....	35	0	13.1	100	17	46.2
Bowl "C:" Untreated.....	100%	40%	90.5%	100%	25%	51.0%

Average daily use of treated (dyed) and untreated corn (bowls "A" and "B" only):

	Per 6 birds	Per bird
For 9 day period.....	249.55	41.59
For 5 day period.....	294.20	49.33

respect to "special acceptance" or of any particular color selection. The only notable selection of colored grain was evidenced by an apparent preference for corn dyed with the Tartrazine Yellow, this even over normal, untreated corn. In both periods of the test, the preference appears to have been of about the same level or threshold of acceptance. During the second period, however, a greater amount of both Tartrazine Yellow dyed and untreated corn was used than during the first period of the test.

Perhaps the most outstanding feature of the two testing periods lies in the wide differences of acceptance of colored grains during the two periods, and from day to day.

It may be concluded that artificially colored grains of corn may be eaten in varying quantities by pheasants, and that the amount eaten varies from day to day, and furthermore, there is daily variation in the proportions of different colors which are consumed. It may be inferred that while "preference" appears to be exhibited by these birds, the range of colors of "special preference" lies within a

very narrow range of the color spectrum, other colored foods may be eaten and without seeming "preference" or respect to any particular color or color influence.

Finally, it would appear from this and other studies, that colored baits can not be used as a repellent or effective deterrent for birds, and this may apply most particularly to most of the gallinaceous birds. At the same time, it may be concluded that any attempt to reduce "pulling" of corn by coloring the seed is virtually useless as a real deterrent.

Some colors may serve to camouflage poisonous baits and thus reduce their consumption by some birds, but the color can hardly be interpreted as being a primary repellent factor.

It would appear that further studies on repellants for use against birds, and especially against gallinaceous birds, should follow an entirely different course of investigation, since color does not appear to be an important or effective repellent or deterrent.

The chief importance in coloring of poisoned baits may be applied to the handling by human-beings, at least to some extent, although this is not always entirely successful.

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